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ECONOMIC EVALUATION OF THE PROMULGATED INTERIM PRIMARY DRINKING WATER REGULATIONS

ENERGY RESOURCES COMPANY, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

OCTOBER 1975

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16. ABSTRACT

An evaluation was performed of the Promulgated Interim Primary Drinking Water Regulations. The results of this study indicate that the annual costs for water monitoring for community systems will be between $12 million and $25 million, while the costs for water monitoring for non-community systems will be between $4.5 million and $9.5 million. Between $1.1 billion and $1.8 billion will be required to build additional treatment facilities for removing contaminants from the nation's drinking waters. It will cost $263 million per year for operation and maintenance of these required facilities. The annual per capita costs for those systems which will require treatment range from $240 for a system serving 25 people and treating for heavy metal removal to under $0.25 per year for systems serving over 100,000 people requiring disinfection. A constraint analysis examined the broad areas of chemicals and supplies, manpower, laboratories, and engineering and construction services.

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CHAPTER ONE

EXECUTIVE SUMMARY

1.0 Safe Drinking Water Act of 1974

The objective of the Safe Drinking Water Act (PL 93-523) is to establish standards which will provide for safe drinking water supplies throughout the United States. To achieve this objective the Congress authorized the Environmental Protection Agency to establish national drinking water regulations. In addition, the Act provides a mechanism for the individual states to assume the primary responsibility for enforcing the regulations, providing general supervisory aid to the public water systems, and inspecting public water supplies.

The purpose of the legislation is to assure that water supply systems serving the public meet minimum national standards for the protection of public health. Prior to passage of the Act, the Environmental Protection Agency was authorized to prescribe Federal drinking water standards applicable only to water supplies used by interstate carriers. Furthermore, these standards could only be enforced with respect to contaminants capable of causing communicable diseases. In contrast, the Safe Drinking Water Act authorized the Environmental Protection Agency to establish regulations to (1) protect public water systems from all harmful contaminants; (2) protect underground sources of drinking water; and (3) promote a joint Federal-State system for assuring compliance with these regulations.

1.1 National Interim Primary Drinking Water Regulations

The EPA published its Proposed National Interim Primary Drinking Water Regulations in the Federal Register, March 14, 1975. The EPA held four public hearings and received several thousand pages of public comments on the proposed regulations. Based upon its review of the comments, the EPA revised the proposed regulations for final publication. The major provisions of the Interim Primary Drinking Water Regulations are:

1. Maximum contaminant levels for certain chemical, biological, and physical contaminants are established;

2. Monitoring frequencies to determine that contaminant levels assure compliance are established;

3. A methodology to notify consumers of variances, exemptions, and non-compliance with standards is set forth.

1.2 The Water Supply Industry

The Safe Drinking Water Act of 1974 covers public water systems that regularly serve an average of 25 people or have at a minimum 15 service connections. Systems that serve the travelling public are considered public water systems under the Act. EPA currently estimates that there are 240,000 public water systems that will be subject to the regulatory requirements developed under the Act.

The Interim Primary Drinking Water Regulations categorize public systems as community and non-community systems. A community system is defined as a public system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents. The non-community system category includes those systems which serve a transient population. At the present time the distribution between the two classes of public systems is estimated as follows:

Community Systems	40,000
Non-Community Systems	200,000
TOTAL	240,000

Based on the data contained in the ongoing EPA Inventory of Public Water Supplies, there are approximately 177 million persons served by community water systems. Table 1-1 shows the distribution of community systems by population served. Most of the community water systems are small in size. Over 90 percent of the nation's supplies are under the 10,000 population served category but they provide water to less than 25 percent of the total population served by community systems.

TABLE 1-1

DISTRIBUTION OF COMMUNITY WATER SYSTEMS

SYSTEM SIZE (PERSONS SERVED)	NUMBER OF WATER SYSTEMS	TOTAL POPULATION SERVED (000's)	PERCENT OF TOTAL POPULATION SERVED
25-99	7,008	420	0.2
100-9,999	30,150	36,816	20.8
10,000-99,999	2,599	61,423	34.6
100,000 and over	243	78,800	44.4
TOTAL	40,000	177,459	100.0

Source: EPA Inventory of Public Water Supplies (July 1975).

While all public systems do not treat all of the water they supply to their customers, they do employ a variety of treatment processes. The current EPA Inventory of Public Water Supplies indicates that the most prevalent treatment processes are used to control bacteriological contamination and turbidity. The percentage of systems employing the various treatment processes is presented in Table 1-2.

Community water systems may be publicly or privately owned. The majority, 58 percent, of the 40,000 community water supplies are publicly-owned and these systems supply 88 percent of the total drinking water production.

As indicated earlier, it is estimated that there are approximately 200,000 public non-community water systems. Most of these systems are privately-owned. Non-community systems are found at service stations, motels, restaurants, rest areas, campgrounds, state parks, beaches, national parks, national forests, dams, reservoirs, and other locations frequented by the travelling public. Some schools and industries are also included in this category. Data on these systems are very sparse, and only rough cost estimates can be made.

TABLE 1-2

TREATMENT PROCESSES EMPLOYED BY COMMUNITY WATER SYSTEMS

TREATMENT	PERCENT[a]
Aeration	6.6
Prechlorination	7.8
Coagulation	11.3
Sedimentation	8.9
Filtration	12.8
Softening	4.9
Taste and Odor Control	3.4
Iron Removal	5.7
Ammoniation	0.9
Fluoride Adjustment	8.5
Disinfection	35.2

[a] Percentages do not total 100 percent since many systems have multiple treatments, or no treatment.

Source: EPA Inventory of Public Water Supplies (July 1975).

The portion of the water supply industry considered here includes only those systems which primarily supply water for residential, commercial, industrial, and municipal use. An approximate allocation of water use by various categories of users is shown in Table 1-3. As might be expected most of the water delivered, 63 percent, is for residential purposes. The second largest use, industrial, consumes 21 percent.

TABLE 1-3

COMMUNITY WATER SUPPLY USE BY CATEGORY

TYPE OF USE	PERCENTAGE OF TOTAL
Residential	63
Commercial	11
Industrial	21
Municipal	5
TOTAL	100

Source: U.S. Geological Survey Data (1972).

1.3 Costs to Meet the Interim Primary Drinking Water Regulations

1.3.1 Monitoring Costs

The implementation of the Interim Primary Drinking Water Regulations will require all public water systems to initiate a monitoring program to determine that the maximum contaminant level requirements of the regulations are not exceeded in finished drinking water. The costs associated with this monitoring activity are a function of system size, water source, and classification (community vs. non-community).

There are two classes of monitoring costs, routine monitoring costs and non-compliance monitoring costs, imposed by the interim regulations. Routine monitoring costs are those incurred in meeting the sampling requirements of the Interim Primary Drinking Water Regulations, to determine compliance with the regulations. Non-compliance monitoring costs are those which are incurred when additional sampling must be made if routine monitoring results indicate that a system is not in compliance with one or more maximum contaminant level.

The Interim Primary Drinking Water Regulations call for the monitoring of four classes of contamination: inorganic, organic, microbiological, and turbidity. The routine monitoring frequencies for community and non-community systems are shown in Tables 1-4 and 1-5.

TABLE 1-4

MONITORING REQUIREMENTS FOR COMMUNITY SUPPLIES
(Interim Primary Drinking Water Regulations)

COMPONENT	SYSTEM TYPE	DEADLINE FOR INITIAL SAMPLING AFTER EFFECTIVE DATE	TEST FREQUENCY
Coliform	Ground & Surface	1 Month	Monthly[a]
Inorganic Chemicals	Surface Ground	1 Year 2 Years	Annually Every three years
Organic Chemicals	Surface Ground	1 Year As specified by by the State	[b] As specified by the State
Turbidity	Surface	1 Day	Daily

[a] Supplies must collect minimum required samples during each month after effective date. The number of samples varies with the system size from 1 to 500 samples per month.

The State may reduce the sampling frequency based on a sanitary survey of a system that serves less than 1,000 persons from a groundwater source, except that in no case shall it be reduced to less than one per quarter.

[b] The analyses shall be repeated at intervals specified by the State but in no event less frequently than at three-year intervals.

TABLE 1-5

MONITORING REQUIREMENTS FOR NON-COMMUNITY SUPPLIES
(Interim Primary Drinking Water Regulations)

COMPONENT	SYSTEM TYPE	DEADLINE FOR INITIAL SAMPLING AFTER EFFECTIVE DATE	TEST FREQUENCY
Coliform	Surface & Ground	2 Years	Quarterly[a]
Inorganic Chemicals-Nitrates Only	Surface & Ground	2 Years	Determined by the State
Turbidity	Surface	2 Years	Daily

[a] May be modified by the State based on Sanitary Survey.

In developing routine monitoring costs, the number of systems requiring routine monitoring is fixed by the number of ground- and surface-water supply systems in each discrete size range and the monitoring frequency prescribed by the regulations. Therefore, the only variable in the cost equation is the price per analysis. This price will depend on the institutional arrangements made by each system for analytical services. At the present time some water supplies perform their own analyses, while others depend on state health agencies or private commercial laboratories. The unit analytical costs developed for the monitoring cost estimates are as follows:

ANALYSIS	COST RANGE ($)
Coliform	5 - 10
Complete Inorganic	70 - 170
Complete Organic	150 - 260

The lower costs are based on costs incurred in EPA laboratories, while the higher costs are based on commercial laboratory estimates.

In developing non-compliance monitoring costs, the critical variable is the number of additional samples required when a system exceeds a maximum contaminant level (MCL). The interim regulations require a minimum of two check samples when the coliform MCL is exceeded and at least three repeat samples when an inorganic or organic MCL is exceeded. In each instance the supplier must continue the sampling procedure until two consecutive samples show that the MCL is not exceeded. For coliform violations it is expected that from two to five special analyses may be needed. For organic and inorganic violations it is expected that from three to six special analyses may be necessary.

The estimated costs for routine and special monitoring for public water systems are summarized in Table 1-6. In the first year of implementation the annual costs are expected to fall in a range of $14 million to $30 million. By the end of the third year when the non-community systems begin to monitor, the annual monitoring costs will rise to a range of $17 million to $36 million. These monitoring cost estimates do not reflect the costs of existing monitoring programs. Current routine monitoring is estimated at approximately $10 million to $17 million annually.

1.3.2 Treatment Costs

Once the monitoring program is initiated, some systems will find that they exceed one or more maximum contaminant levels (MCL). These systems will then be faced with an additional cost in order to meet the required MCL. There are several alternative routes which a system can pursue in order to comply with the regulations. Some of the alternatives include:

1. Installing treatment facilities capable of reducing the MCL to an acceptable level;
2. Developing a new source of supply of better quality;
3. Purchasing better quality water from another water utility; or
4. Merging the system with one or more adjoining systems which have a higher quality supply.

If none of the above is feasible, a system can apply for a variance or exemption to the MCL under the provisions

TABLE 1-6

TOTAL MONITORING COSTS MANDATED BY THE INTERIM PRIMARY DRINKING WATER REGULATIONS

($ million)

	FIRST YEAR	SECOND YEAR	THIRD YEAR
Costs of Routine Monitoring for the 40,000 Community Systems[a]	13.3 - 27.3	12.7 - 26.3	12.3 - 25.5
Monitoring Due to Violations of MCL for 40,000 Community Systems			
i) Coliform Violation Monitoring	0.5 - 2.0		
ii) Inorganic Violation Monitoring	0.01 - 0.3	0.01 - 0.3	
Routine Monitoring Costs for the 200,000 Non-Community Systems[b]			4.5 - 9.4
Monitoring Due to Violations of MCL for 200,000 Non-Community Systems[c]			0.3 - 0.8
TOTAL	14 - 30	13 - 27	17 - 36

[a] Annual costs beginning the first year after implementation of the regulations.

[b] Annual costs beginning the third year after implementation of the regulations.

[c] Total monitoring costs due to violations spread over a 2-year period.

Note: Totals may not add due to rounding.

of the interim primary regulations. Therefore, the costs incurred by a water supply in reducing the concentration of a contaminant to an acceptable level are site specific and will depend on such factors as treatment facilities available, age of system, proximity of other suppliers, source of water, and many other interrelated problems.

However, in projecting national costs for treatment the option of installing treatment facilities was assumed to be the method systems would select to provide safe drinking water.

The following basic assumptions are implicit in developing costs for the treatment options:

1. Surface water systems not presently clarifying will install some form of filtration;
2. Approximately 30 percent of the community water systems not presently disinfecting will install chlorination units;
3. Advanced treatment is necessary to remove inorganics;
4. Estimates of the number of MCL violations were based on the 1969 Community Water Supply Study, except for mercury. Mercury violations were based on recent EPA studies.

The national treatment costs for public water systems are summarized in Table 1-7. The majority of costs, if all systems elect to treat for contaminant violations, will be incurred in order to meet the turbidity and inorganic requirements of the interim regulations. Ranges were developed for capital costs only. This range is based on making two assumptions for daily flow. If a system were required to install treatment, it would have to consider sizing the new components to reflect average daily flow conditions or maximum daily flow conditions in cases where system storage is not adequate. Whatever sizing option a system selected, it is unlikely that significant additional operation and maintenance expenses would result.

1.4 Economic Impact of the Interim Primary Drinking Water Regulations

The expenditures required to comply with the interim primary regulations will have an impact on all water users

TABLE 1-7

NATIONAL COSTS OF TREATING CONTAMINANTS IN DRINKING WATER

($ million)

TREATMENT TECHNOLOGY	CONTAMINANT	CAPITAL COSTS	ANNUAL O&M
COMMUNITY SYSTEMS			
Clarification	Turbidity	379 - 683	189
Chlorination	Coliform	17 - 27	7
Ion Exchange	Ba, Cr, Cd, NO_3, Hg, Se	619 - 997	52
Activated Alumina	As, Fluoride	31 - 53	11
pH Control	Pb	3 - 4	0.1
SUBTOTAL		1,049 - 1,764	259
NON-COMMUNITY SYSTEMS			
Clarification	Turbidity	10	1
Chlorination	Coliform	14	3
SUBTOTAL		24	4
TOTAL		1,073 - 1,788	263

Note: Totals may not add due to rounding.

served by public water supplies covered by the Safe Drinking Water Act. All persons served by these systems will feel the impact of monitoring costs to some extent. However, the most noticeable impact of the regulations will be on users of public water systems that do not meet the MCL requirements of the regulations.

An estimate of the total annual costs of capital, operation and maintenance, and monitoring necessary to comply with the regulations is shown in Table 1-8.

TABLE 1-8

ESTIMATED TOTAL ANNUAL COSTS OF IMPLEMENTING THE INTERIM PRIMARY DRINKING WATER REGULATIONS FOR PUBLIC WATER SYSTEMS
($ million)[a]

Annual Capital[b]	146 - 247
Annual Operation & Maintenance	263
Annual Monitoring (Routine)	17 - 35
TOTAL ANNUAL	426 - 545

[a] 1975 dollars.

[b] Assumes capital costs amortized over 15 years at 7 percent interest.

1.4.1 Water Supply Economics

The price consumers pay for water is determined, in general, by costs the utility incurs to operate and maintain the system. However, some publicly-owned water systems may have their costs and revenues conglomerated with the cost of other municipal services, and the water bill paid by the consumer may not completely reflect the status of the water system alone.

Water system rate structures vary from system to system, and may also differ for various user classes within the same system. There are four basic types of rate structures which are used around the country. Some systems use a "normal block" structure which results in lower unit costs to customers that use high volumes of water. In the "inverted block" structure, higher unit costs are imposed upon customers who use higher volumes of water. Under a "flat" rate structure, there is one single charge per unit for all customers regardless of use. Generally, the flat rate structure applies to residential customers only. Finally, in the "non-incremental" rate structure, the unit cost of water is based on the number of water consumption units owned by the user.

Prices charged for water are usually regulated by a state or local commission appointed to evaluate the need for rate hikes. In most states, investor-owned utilities are under the jurisdiction of state regulatory commissions. Publicly-owned utilities are either regulated by local boards or are unregulated. Any lengthy lag time between rate increase requests and rate increase approvals may pose problems in the implementation of the interim regulations.

Most water utilities, both public and private, finance large capital investments by retaining profits or acquiring debt. Publicly-owned systems may have access to municipal funds or can sell either general obligation or revenue bonds to be repaid from general revenues or water revenues. Private, investor-owned systems may issue stocks and bonds, and unlike publicly-owned systems, their credit ratings are dependent on the profitability of their own operations. Since interest rates are generally proportional to risk, water utilities in more secure financial positions can borrow money at lower interest rates. At the present time the interest rate on municipal bonds is 4 to 6 percent, while the rate for debt issues of privately-owned utilities is 6 to 8 percent.

In the water industry there does not seem to be a correlation between present debt levels and long-term financial soundness. Although a majority of water systems today have debt ratios ranging upward from 40 percent, almost one-fourth of the water systems are presently debt-free. Approximately 85 percent of these debt-free systems serve communities of less than 5,000 people. However, many of these small systems do not have a positive net income, while larger water systems with high debt to book value ratios do have positive net income.

Records indicate that per capita consumption of water tends to decrease following significant increases in water rates. Among individual users the decrease would occur where there is a high elasticity of demand, e.g., lawn sprinkling. Industrial and commercial users have shown no elasticity to price increases. If demand declines sharply after initial rate hikes, and total revenues do not rise to cover costs, a second increase may be necessary.

1.4.2 Per Capita Costs

Monitoring costs vary with the size of the water system involved. The number of samples for routine bacteriological monitoring is a function of the number of persons served. For community supplies the number of samples can range from a minimim of 1 sample per quarter for systems serving 1,000 people or less to a maximum of 500 samples per month for systems serving more than 4,690,000 people. For non-community supplies only one sample per quarter is required.

In general, the annual impact of routine chemical monitoring will vary depending on the frequency of sampling rather than the number of samples. The frequency of sampling will depend on the system type: groundwater vs. surface water; community system vs. non-community. The annual monitoring costs on a per capita basis are shown in Table 1-9. The per capita costs for the smallest community system (25 persons served) are high in comparison to other system sizes. However, there are very few systems in this category and the states may desire to enter into institutional arrangements to lessen their annual monitoring burden.

TABLE 1-9

ANNUAL MONITORING COSTS PER PERSON SERVED VERSUS SYSTEM SIZE AND TYPE FOR COMMUNITY WATER SYSTEMS

SYSTEM SIZE	SYSTEM TYPE SURFACE ($)	 GROUND ($)
25	7.20 - 15.05	3.35 - 7.05
100	1.80 - 3.75	0.85 - 1.75
500	0.35 - 0.75	0.15 - 0.35
1,000	0.20 - 0.40	0.10 - 0.20
2,500	0.15 - 0.30	0.05 - 0.15
5,000	0.10 - 0.25	0.05 - 0.15
10,000	0.10 - 0.20	0.05 - 0.15
100,000	0.05 - 0.15	0.05 - 0.15
1,000,000	a - 0.05	a - 0.05
10,000,000	a - a	a - a

[a] Less than $0.05.

However, treatment costs may be responsible for much higher per capita cost increases than monitoring costs. As indicated earlier, public water systems not meeting the MCL requirements of the interim regulations will incur the major cost burden. The impact of the treatment costs will also vary with the size of the water system involved. Table 1-10 summarizes the treatment costs as they affect systems of different sizes.

It should be pointed out that the per capita costs displayed in Table 1-10 are weighted averages. Treatment costs have been weighted by the projected frequency of the various treatment techniques within each size subcategory. But its nature, the weighted average does not give a true representation of the costs to a particular consumer. In all categories, there are five treatments possible with a wide variation in costs. In Table 1-11, the range of annual per capita monitoring and treatment costs is presented. From this table it can be seen that the annual per capita treatment costs for disinfection are expected to range from $3.85 to $2.10 in the Smallest system category, from $2.75 to $0.30 in the Small system category and so on.

1.4.3 Impact Analysis

As Tables 1-10 and 1-11 demonstrate, the potentially most severe impact could occur for users of the smallest or small systems. Assuming that treatment and monitoring costs are directly passed on to the consumer, the monthly water bill for a household in the smallest systems may increase on the average between $10 and $14.

However, as noted earlier, these systems may choose not to install treatment facilities in order to comply with the regulations. Several options are available to them:

1. Developing a new, less contaminated source;
2. Joining a regional system;
3. Purchasing treated water; or
4. Blending water from existing source with water of higher quality.

The exemption and variance provisions of the Act provide for temporary immunity from the regulations on the basis of economic hardship or technical difficulties. Federal loan

TABLE 1-10

DISTRIBUTION OF COSTS FOR THOSE SYSTEMS NEEDING TREATMENT BY SYSTEM CATEGORY

	SMALLEST SYSTEMS (25-99 PEOPLE SERVED)	SMALL SYSTEMS (100-9,999 PEOPLE SERVED)	MEDIUM SYSTEMS (10,000-99,999 PEOPLE SERVED)	LARGE SYSTEMS (Over 100,000 PEOPLE SERVED)
Annual Capital Costs ($ million)	3.8 - 6.4	60.2 - 101.4	52.3 - 88.1	30.5 - 51.2
Annual O&M Costs ($ million)	2.1	48.6	74.1	134.1
Annual Monitoring Costs ($ million)	0.3 - 0.6	0.6 - 1.3	1.2 - 2.5	1.3 - 2.9
TOTAL ANNUAL COSTS ($ million)	6.2 - 9.1	109.4 - 151.3	127.6 -164.7	165.9 -188.2
Weighted Average Costs per Capita per Year ($)	37 - 54	11 - 15	9 - 12	10 - 11
Increase in Household Monthly Water Bill ($)[a]	9.60-14.05	2.85- 3.95	2.35- 3.95	2.55- 2.90

[a] Assumes 3.11 persons per household and that all increases in costs are passed on to the consumer.

TABLE 1-11

ANNUAL PER CAPITA AND MONITORING COST RANGES FOR FOUR SIZE CATEGORIES

	SMALLEST SYSTEMS (25-99 PEOPLE SERVED)	SMALL SYSTEMS (100-9,999 PEOPLE SERVED)	MEDIUM SYSTEMS (10,000-99,999 PEOPLE SERVED)	LARGE SYSTEMS (OVER 100,000 PEOPLE SERVED)
TREATMENT[a]				
Disinfection	3.85 - 2.10	2.75 - 0.30	0.45 - 0.15	≤ 0.25
Turbidity Control	152.00 - 52.00	78.00 - 16.00	20.00 - 12.50	≤15.00
Heavy Metal Removal	237.00 - 101.00	142.00 - 25.50	35.00 - 13.00	≤18.00
Lead Control	2.60 - 1.20	1.80 - 0.30	0.40 - 0.20	≤ 0.30
Fluoride/Arsenic Removal	11.80 - 7.85	11.30 - 3.15	5.00 - 3.15	≤ 3.55
MONITORING	15.80 - 0.85	3.75 - 0.05	0.20 - 0.05	≤ 0.05

[a] Lower cost limit based on assumption that treatment plant built to treat average daily demand and upper cost limit based on maximum daily demand, except for the Smallest Systems category where costs are based on average daily demand only.

programs may also ease the impact on users of small systems. The Farmers Home Administration sponsors a loan and grant program to aid the financing of water and sewer system construction in small communities. The loans are offered at low interest rates and with long repayment schedules. The Safe Drinking Water Act also authorizes a loan guarantee program for small systems. These programs will reduce community costs, but they will not completely mitigate the possibility of high cost impacts on households in small systems.

It is not certain how systems will finance the costs associated with these regulations -- either through higher taxes or higher water rates -- but it is certain that the Interim Primary Drinking Water Regulations will have the greatest impact on those served by smaller water systems. Further study is underway to determine if financing will be a serious problem for large or small systems.

At the present time EPA believes that the economic impact of the construction requirements will be spread over at least a 4-year period from the promulgation of the regulations because the regulations will not result in immediate compliance. The effective date of the regulations will be 18 months after promulgation. Non-compliance may not be discovered until initial sampling has been completed. For community water supplies the deadlines for initial sampling range from one day for turbidity to two years for inorganic samples of groundwater systems after the effective date. Therefore, in some cases, more than three years from promulgation could elapse before inorganic violations would be detected and corrective actions initiated. In addition, the use of the exemption or variance provisions of the regulations could further prolong compliance for public water systems unable to comply for economic or technical reasons.

It is estimated that the investor-owned water systems will pay approximately one-fourth of the total treatment costs, while the publicly-owned companies would pay the remainder. However, since many of the investor-owned systems serve very small populations, the capital demands on these systems could be great.

In 1974, the water supply industry spent approximately $1.5 billion for capital improvements. The average yearly total annual capital costs mandated by the interim primary regulations are estimated to be about 13 to 24 percent of this figure. It is anticipated that the industry as a whole would be able to raise the additional necessary capital. Small systems could encounter difficulty in financing new treatment facilities, particularly when clarification, a relatively expensive treatment process, is required. The implementation of these regulations may force many communities to allocate funds, which may be needed to provide other services to the community, for the treatment of their drinking water.

Data on non-community systems are sparse. However, it is not anticipated that these regulations will have a serious economic impact on them.

The macroeconomic effects of the Interim Primary Drinking Water Regulations are expected to be minimal. On the average, the regulations will cause an increase in water rates of 9.5 percent spread over several years. If this increase occurred in 1 year, the resulting increase in the Consumer Price Index (CPI) would be less than 0.001 percent. Since the costs of these regulations will be incurred over several years, the average annual increase in the CPI will be even less. The Chase Econometric model was used to examine the impact of all existing pollution abatement regulations.[1] The analysis showed that there will be an average annual increase in the CPI for 1974 to 1980 of less than 0.1 percent due to these pollution abatement regulations.

1.5 Constraints to Implementation of the Interim Primary Drinking Water Regulations

The implementation of the National Interim Primary Drinking Water Regulations within a reasonable time frame would greatly depend on the availability of key chemicals and supplies needed in the treatment of drinking water; availability of manpower to operate treatment facilities; adequate laboratory capability to conduct sample analyses; and sufficient supply of engineering and construction services to build or improve treatment facilities.

In particular, the interim regulations will increase demand for coagulants and disinfecting agents as the needed treatment facilities are completed. An increased demand could cause some temporary dislocations in chemical markets, but in the long run, increased demand will result in an expansion of supplies. It is projected that the 1980 demand for ferric chloride may reach 115 to 120 percent of the present production, while alum demand will be approximately 115 percent of current production. There is a general consensus of opinion that organic polyelectrolytes will become the dominant flocculating agents in the future. However, there are no reliable estimates of which polyelectrolyte(s) will be dominant and when the shift in chemical usage will occur.

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[1] Chase Econometric Associates, Inc., "The Macroeconomic Impacts of Federal Pollution Control Programs," prepared for the Council of Environmental Quality and the Environmental Protection Agency, January 1975.

At the present time there are approximately 180,000 people employed in the water supply industry. With the implementation of the Interim Primary Drinking Water Regulations between 13,000 and 27,000 additional personnel would be needed nationwide. These personnel would be required to perform such tasks as monitoring and enforcing the regulations, operating the required treatment facilities, performing laboratory analysis of water samples, program assistance, and program administration. It is anticipated that water systems may have difficulty hiring qualified personnel.

The third potential constraint is in the availability of adequate laboratories to perform the required chemical and biological analyses. Coliform monitoring is now being performed at state, local, and private laboratories. In meeting the coliform monitoring requirements, water suppliers should not have difficulty finding laboratory facilities. At the present time there is little routine monitoring being done for heavy metals and organic compounds of concern in the regulations. However, there are adequate numbers of public and private laboratories capable of performing these analyses although state certification of laboratories, required by the regulations, could constrain available laboratory facilities.

The final area where constraints could occur is in the design and construction of the required treatment facilities. Although the annual cost of required new construction represents less than 0.4 percent of the present total annual new construction in the United States, design and construction of new water treatment plants is highly specialized. Some communities, especially those in rural areas, may have difficulty obtaining these services due to their expense or unavailability.

1.6 Limits of the Analysis

In developing the cost estimates used in this study, it was necessary to use several simplifying assumptions. This section explores these assumptions and what their overall impact might be.

The first assumption is that there are 40,000 community water supply systems in the nation and that they are represented accurately by the current EPA Inventory of Community Water Supplies. There is some evidence that when the inventory is completed there will be a total of 50,000 community systems rather than the estimated 40,000. This increase in systems would cause an increase in monitoring costs of about 12 percent and a similar increase in treatment costs.

All costs for public non-community systems were based on the assumption that there are 200,000 of these systems nationwide. At the present time there is no accurate inventory of these systems, thus, this number is solely an estimate. It is anticipated that the EPA will be performing an inventory of these systems in the next few years so that these estimates can be updated.

A major consideration not used in developing treatment costs is that many systems may use alternative water management practices rather than install more costly treatment processes when they exceed an MCL requirement. For example, groundwater systems might blend water from a "clean" well with that from a "dirty" well so that the resultant water will not exceed the MCL. Similarly, no estimate is possible to determine the possible benefits which might result from cascading treatment processes. An example of this is that clarification units might remove enough heavy metals so that the MCL might not be exceeded. These treatment alternatives would vary from site to site so that it is impossible to quantify the benefits which would be derived.

1.7 Energy Use

It is estimated that approximately 21,200 billion Btu's per year will be required to operate plants and produce chemicals for the various treatment systems necessary for the 40,000 community systems to meet the regulations. This is about 0.028 percent of the 1973 national energy consumption, based on the 1974 Statistical Abstract. The increase in energy use will depend on a number of factors, including whether pollution in surface sources of water is successfully controlled. There will be no direct energy savings from the recommended action.

CHAPTER TWO

INTRODUCTION

2.0 Safe Drinking Water Act of 1974

The objective of the Safe Drinking Water Act (PL 93-523) is to provide for the safety of drinking water supplies throughout the United States through the establishment and enforcement of national drinking water regulations. The Congress has authorized the Environmental Protection Agency to promulgate national drinking water regulations. The individual states will have the primary responsibility of enforcing the regulations, providing general supervisory aid to the public water systems, and inspecting all sources of drinking water.

The major provisions of the Safe Drinking Water Act can be summarized as follows:

1. Establishment of primary drinking water regulations for the protection of the public health;
2. Establishment of secondary regulations relating to odor and appearance of drinking water;
3. Establishment of protective measures for underground drinking water sources;
4. Research to evaluate health, economic, and technological problems including studies of viruses and contamination by cancer-causing chemicals in drinking water supplies;
5. Performance of a survey of rural water supplies;
6. Aid to the states to improve drinking water programs through technical assistance, training of personnel, and grant support. A loan guarantee is provided to assist small water systems in meeting regulations;
7. Establishment of a procedure for citizen suits against any party believed to be in violation of the Act;

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8. Establishment of procedures for record-keeping, inspections, issuance of regulations, and judicial review;

9. Establishment of a 15-member National Drinking Water Advisory Council to advise the Administrator of EPA on scientific and other responsibilities under the Act;

10. Requirement that the Secretary of Health, Education, and Welfare either insure that the standards for bottled drinking water conform to the primary regulations established under the Act or publish reasons for not doing so;

11. Authorization of appropriations totalling $156 million for fiscal years 1975, 1976, and 1977.

2.1 Promulgated Interim Primary Drinking Water Regulations

The Congress mandated that the Environmental Protection Agency establish the Interim Primary Drinking Water Regulations within six months after passage of the Act. The major provisions of the interim regulations can be summarized as follows:

1. Establish definitions of the two types of "public" water supply systems;
2. Set range of applicability and coverage of standards;
3. Establish monitoring frequencies;
4. Indicate suitable analysis techniques;
5. Establish maximum contaminant levels for certain inorganic, organic, and biological substances;
6. Establish a laboratory approval requirement;
7. Establish a methodology to notify consumers of variances, exemptions, and non-compliance with standards;
8. Establish reporting requirements for systems failing to comply with the regulations;

9. Establish reporting requirement for locating future water supplies;

10. Set the effective date 18 months after promulgation of the regulations.

A copy of the Promulgated Interim Primary Drinking Water Regulations can be found in Appendix A.

2.2 Study Objective

The objective of this study is to provide an analysis of the effects of implementing the Promulgated Interim Primary Drinking Water Regulations. Chapter Three briefly describes the history and characteristics of the water supply industry as well as relevant information on the data bases used in this study.

Chapter Four develops the total national costs for monitoring the 40,000 community systems and 200,000 public, non-community systems. This chapter also develops the costs of treatment for those systems which exceed one or more maximum contaminant levels.

Chapter Five predicts the manner in which the monitoring and treatment costs would be spent over the next 10 years and examines the feasibility of financing these costs. The chapter also examines the financial structure of the industry and the availability of funding for the incurred costs.

Chapter Six examines the impact of the monitoring and treatment costs both separately and cumulatively. This chapter shows the distribution of costs among the commercial, municipal, industrial and residential sectors. The impact on both the private (investor-owned) sector and the public sector is also explored, as are the cost effects on different size systems (measured in terms of population served).

Chapter Seven explores those non-economic variables which might act as constraints to implementation of the Interim Primary Drinking Water Regulations. In particular, the study examines the availability of manpower, key materials, and laboratories.

Chapter Eight elucidates the major assumptions used in this report and places limits on the effects of the assumptions. This chapter draws the overall analysis into perspective.

CHAPTER THREE

THE WATER SUPPLY INDUSTRY

3.0 General Description

The water supply industry, classified by the Department of Commerce as SIC group 4941, maintains facilities to supply water primarily for municipal, residential, commercial, and industrial use. This classification excludes facilities which provide water for irrigation. The present study deals with that portion of SIC group 4941 providing water for general community usage.

The water supply industry produces more tons of finished goods (approximately 85 million tons daily) than any other U.S. industry. It is estimated that in 1970 public water supplies delivered over 27 billion gallons of water per day (bgd), of which about 63 percent was used for residential purposes.[1]

The first municipal water purification plant built in the United States was constructed in Virginia in 1832 and was the forerunner of several hundred plants built during the 1800's. The evolution of organized public systems in the 19th century was closely related to the growth of cities and towns around industrial developments. Water system management by private water companies became prevalent and service was continuously improved. By the end of the century publicly operated water utilities were more numerous and delivered an increasing volume of water to the growing cities of America. In 1900 about 22 million people were being served by public water systems.[2]

The development of water utilities during the past 75 years has paralleled that of other essential service industries. At the present time there are an estimated 40,000 community

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[1] C.R. Murray and E.B. Reeves, Estimated Water Use in the U.S. - 1970, U.S. Geological Survey, Department of the Interior, 1972.

[2] American Water Works Association - Staff Report, "The Water Utility Industry," April 1966.

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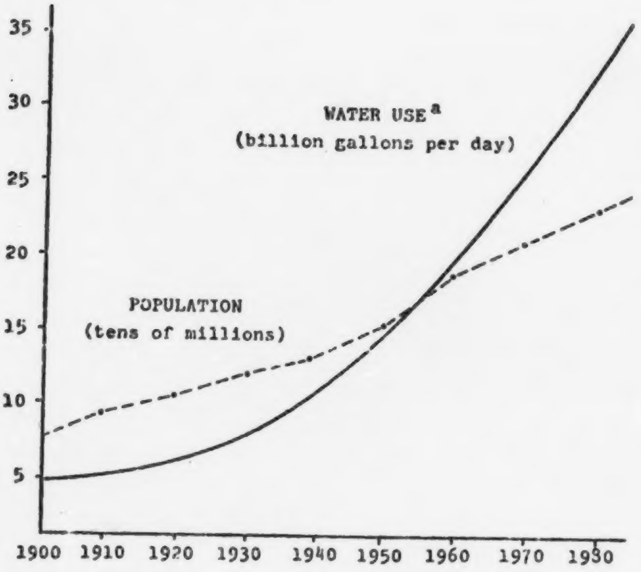
water supply facilities in the United States serving approximately 177 million people each day. By 1980 the needs of public water utilities are expected to increase to about 33.6 bgd. Water usage in the public water utility industry for the period 1900-1980 is shown in Figure 3-1.



[a]There are 0.00378 m^3 per gallon.

Figure 3-1. This graph illustrates public water utility water needs for the years 1900 to 1980. (*CRC Handbook of Environmental Control*, vol. III: *Water Supply & Treatment*, 1973, p. 131.) (Population data from: *Social Indicators 1973*, Office of Management and Budget, 1973, p. 233.)

3.1 Community Water Systems

The regulations define the term "public water system" as a system for the provision to the public of piped water for human consumption, if such a system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. The term "community water system" is defined as a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 residents throughout the year. A non-community water system is defined as a public water system that is not a community water system.

Community water systems and public non-community water systems are treated separately due to the great disparity in the amount of data available on each of them.

In this study the EPA estimate of 40,000 community water supply systems was used as a valid approximation, although it is quite possible that the EPA will change this estimate when the ongoing EPA inventory is more complete. The EPA inventory of community water supplies has been assumed to be representative of the nation as a whole with respect to population served, treatment facilities, and source of water. The analysis presented here is based on the inventory as of July 1975.

3.1.1 Production

The number of plants and total daily production for seven size categories are shown in Table 3-1. This table shows that while 68 percent of the plants are in the two smallest categories, they contribute only 2.1 percent of total water production. In contrast, the largest 1.2 percent of the plants provide almost 62 percent of the total national community water production. Total plant production is an important variable in the industry because it is responsible for economies of scale in both the capital and O&M costs of treatment.

Nationwide, community water supply systems provide approximately 63 percent of their water service for residential purposes. There are regional variations which are partly due to differences in per capita consumption and partly due to differences in industrial consumption.

3.1.2 Organization

Although the water supply industry provides a universally essential product, it is an atypical industry in many respects. Production in the industry increased first to keep

TABLE 3-1

NUMBER OF WATER SYSTEMS AND DAILY PRODUCTION FOR SEVEN PRODUCTION CATEGORIES

PRODUCTION CATEGORY (Millions of Gallons Per Day)[a]	COMMUNITY SYSTEMS		PRODUCTION	
	NUMBER	% OF TOTAL	MILLIONS OF GALLONS PER DAY	% OF TOTAL
<.01	8,875	22.2	43	0.1
.01-0.1	18,331	45.8	624	2.0
0.1-1.0	9,300	23.2	2,957	9.1
1.0-10.0	3,036	7.6	8,608	27.0
10.0-30.0	325	0.8	5,477	17.2
30.0-50.0	69	0.2	2,232	7.0
>50.0	64	0.2	11,958	37.6
TOTAL	40,000	100.0	31,899	100.0

[a] There are 0.00378 m^3 per gallon.

pace with a geographically expanding agrarian society, and then to keep pace with a growing, more densely populated urban industrial society. In the course of this expansion a variety of water utility types evolved. These different types include full-service, distribution only, water wholesalers, holding companies, and individual community water supplies.

Community water supplies are either publicly-owned or investor-owned. Public supplies may be either self-supporting or tax-supported, while investor-owned utilities are self-supporting enterprises. Because of greater risk and the lack of tax-exempt status, the investor-owned companies have a higher cost of capital. Thus, they generally charge higher rates per unit than do the municipal systems. Table 3-2 displays the number of water systems and their daily production by size and ownership. Of the 40,000 community systems presently supplying water, the data indicate that 58 percent are publicly-owned and that 42 percent are investor-owned. Also, 88 percent of the production is from publicly-owned plants, with private plants contributing about 12 percent.

In many regions the large metropolitan area utilities not only manage all aspects of water supply to major population centers, but they also sell water to distribution companies servicing smaller, outlying cities and towns. Large metropolitan area water utilities are able to take advantage of economies of scale in meeting the costs of maintaining facilities, developing new water sources to meet growing demands, and constructing additional treatment facilities. Since smaller public water systems have higher unit costs and are also limited in their ability to adjust to rising capital needs, they are sometimes consolidated into larger water districts or are absorbed into larger utilities.

3.2 Public Non-Community Water Supply Systems

There is very little information available about the estimated 200,000 public non-community water systems -- systems which serve drinking water to the transient public. These systems are found at service stations, motels, restaurants, rest areas, campgrounds, state parks, beaches, national parks, national forest reserves, dams, reservoirs, and other locations daily frequented by the travelling public. (Appendix B gives an estimated breakdown of these 200,000 systems by use category and population served.)

TABLE 3-2

NUMBER OF WATER SYSTEMS AND DAILY PRODUCTION BY SIZE AND OWNERSHIP

SIZE mgd	NUMBER OF PLANTS		DAILY PRODUCTION mgd[a]	
	PUBLIC	PRIVATE	PUBLIC	PRIVATE
VERY SMALL <0.1	12,366	14,810	416	252
SMALL 0.10-10	10,508	1,828	10,061	1,446
MEDIUM 10-30	272	55	4,571	906
LARGE >30	114	47	13,097	1,094
TOTAL	23,260	16,740	28,145	3,698

[a] There are 0.00378 m^3 per gallon.

The National Sanitation Foundation has estimated[1] the number of public non-community water supply systems in each state. These numbers are displayed in Table 3-3, Column 1. The information was obtained from the following sources:

1. An NSF survey by questionnaire to each state in January 1974. Forty-two states responded. Some of the states did not estimate the number of "Other Systems."

2. An EPA Regional Office survey by direct contact with the states in each region in 1970.

3. A Conference of State Sanitary Engineers survey conducted with the assistance of EPA in January 1973. Twenty-six states responded.

4. A 1974 NSF estimate of "Other Systems" in the seven states which did not respond to any of the above. This estimate was made by assuming one system for each 2,500 population. The 2,500 factor was arrived at by taking the number of "Other Systems" reported for each state in the 1974 NSF survey, dividing it into the total population for that state, and then averaging the results.

Because the NSF survey was made in 1974, data from that questionnaire are used whenever they are available.

In addition, the results of a survey of state water supply agencies in April 1975 pertinent to this category of public water supply systems is provided in Table 3-3, Column 2 (see Appendix C for the survey). Inspection of this table (the case of Texas is the most obvious example) reveals that accurate data on the number of non-community water supply systems have not been compiled, and that more extensive state-by-state investigations will be necessary.

Table 3-4 gives a breakdown by source of water for those non-community systems where extensive data on water quality and system usage are available, while Table 3-5 provides a breakdown by source of water of systems found in the state survey. At the present time, the National Park

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[1] National Sanitation Foundation, Staffing and Budgetary Guidelines for State Drinking Water Supply Agencies (Ann Arbor, Michigan, 1974).

TABLE 3-3

ESTIMATED NUMBER OF PUBLIC NON-COMMUNITY WATER SYSTEMS BY STATE

	POPULATION (x10)^3	COLUMN 1 (NSF STUDY)	COLUMN 2 (ERCO SURVEY)
ALABAMA	3,444	20,100	
ALASKA	300	800	N
ARIZONA	1,770	800	N
ARKANSAS	1,923	1,350	
CALIFORNIA	19,953	1,900	3,000
COLORADO	2,207	1,300	N
CONNECTICUT	3,031	1,200	
DELAWARE	548	401	
DISTRICT OF COLUMBIA			
FLORIDA	6,789	2,716	5,000
GEORGIA	4,589	1,394	1,000
HAWAII	768	9	N
IDAHO	712	258	1,053
ILLINOIS	11,113	1,026	4,600
INDIANA	5,193	10,185	10,000
IOWA	2,824	615	N
KANSAS	2,246	900	1,220
KENTUCKY	3,218	2,100	N
LOUISIANA	3,641	2,000	
MAINE	992	2,450	N
MARYLAND	3,992	1,569	4,100
MASSACHUSETTS	5,889	2,276	N
MICHIGAN	8,875	15,731	16,010
MINNESOTA	3,804	2,675	
MISSISSIPPI	2,216	330	
MISSOURI	4,676	8,100	
MONTANA	894	1,700	N
NEBRASKA	1,483	1,050	N
NEVADA	488	779	
NEW HAMPSHIRE	737	1,700	
NEW JERSEY	7,168	5,200	N
NEW MEXICO	1,016	2,000	N
NEW YORK	18,236	35,000	N
NORTH CAROLINA	5,082	4,833	N
NORTH DAKOTA	617	250	N
OHIO	10,652	20,000	19,100
OKLAHOMA	2,559	1,000	4,000
OREGON	2,091	9,510	
PENNSYLVANIA	11,793	23,945	11,800
RHODE ISLAND	946	60	N
SOUTH CAROLINA	2,590	1,552	1,378
SOUTH DAKOTA	665	270	
TENNESSEE	3,923	1,500	
TEXAS	11,196	2,100	10,150
UTAH	1,059	420	505
VERMONT	444	3,300	3,100
VIRGINIA	4,648	9,375	9,400
WASHINGTON	3,409	2,500	2,050
WEST VIRGINIA	1,744	18,010	210
WISCONSIN	4,417	18,010	
WYOMING	332	600	426
TOTAL		230,387	

N means no answer.
No entry indicates lack of response.

TABLE 3-4

SOURCE OF WATER FOR 11 STUDIES OF PUBLIC NON-COMMUNITY WATER SYSTEMS*

STUDY	SOURCE OF WATER SURFACE	 GROUND	 PURCHASED	 TOTAL
Bureau of Reclamation[a]	28	25	5	58
Water Resource[b]	11	45	0	56
Interstate[c]	0	114	5	119
Park Service[d]	6	36	0	42
Forest Service[e]	26	93	0	119
Kansas Evaluation[f]	0	37	3	40
Florida Evaluation[g]	0	78	0	78
Kentucky Evaluation[h]	9	50	0	59
Tennessee Evaluation[i]	0	64	0	64
Georgia Evaluation[j]	0	81	0	81
Wyoming Evaluation[k]	1	12	0	13
TOTAL	81	635	13	729

*See following page for references.

[a] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems at Bureau of Reclamation Developments, EPA-430/9-73-004, June 1973.

[b] U.S. Environmental Protection Agency, Office of Water Programs, Sanitary Survey Of Drinking Water Systems on Federal Water Resource Developments, A Pilot Study, August 1971.

[c] U.S. Environmental Protection Agency, Water Supply Division, Drinking Water Systems On and Along the National System of Interstate and Defense Highways, A Pilot Study, 1972.

[d] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems in the National Park Service System, EPA-520/9-74-016, December 1974.

[e] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems in the U.S. Forest Service System, November 1974.

[f] U.S. Environmental Protection Agency, Region VII, Water Supply Program, Evaluation of the Kansas Water Supply Program, 1972.

[g] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, Evaluation of the Florida Water Supply Program, 1973.

[h] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, Evaluation of the Kentucky Water Supply Program, May 1972.

[i] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, Evaluation of the Tennessee Water Supply Program, January 1971.

[j] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, Evaluation of the Georgia Water Supply Program, July 1973.

[k] U.S. Environmental Protection Agency, Region VIII, Water Supply Branch, Evaluation of the Wyoming Water Supply Program, December 1972.

TABLE 3-5

NUMBER OF NON-COMMUNITY SYSTEMS BY SOURCE

	SURFACE WATER	GROUNDWATER
ALABAMA		
ALASKA	N	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	N	N
COLORADO	N	95
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	100
HAWAII	N	N
IDAHO	175	878
ILLINOIS	100	4,500
INDIANA	N	10,000
IOWA	N	N
KANSAS	20	1,200
KENTUCKY	N	N
LOUISIANA		
MAINE	N	N
MARYLAND	2	4,100
MASSACHUSETTS	N	N
MICHIGAN	10	16,000
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	N
NEVADA		
NEW HAMPSHIRE	N	
NEW JERSEY	N	N
NEW MEXICO	N	N
NEW YORK	N	N
NORTH CAROLINA	N	N
NORTH DAKOTA	N	N
OHIO	100	19,000
OKLAHOMA	0	4,000
OREGON		
PENNSYLVANIA	0	11,800
RHODE ISLAND	N	N
SOUTH CAROLINA	25	1,353
SOUTH DAKOTA	2	600
TENNESSEE		
TEXAS	150	10,000
UTAH	5	500
VERMONT	100	3,000
VIRGINIA	0	9,400
WASHINGTON	50	2,000
WEST VIRGINIA	N	200
WISCONSIN		
WYOMING	16	410
TOTALS	758	99,136

N is not known.
No entry indicates lack of response.

Service is completing a national survey of all drinking water systems maintained by that service; however, it will be several months before the results of this study are known. Until the completion of the Park Service study, this sparse sample contains the only data which can be utilized to project national cost trends for the estimated 200,000 systems serving the travelling public.

CHAPTER FOUR

COSTS OF COMPLIANCE

4.0 Introduction

Compliance with the requirements of the Safe Drinking Water Act is expected to involve large expenditures of money. All systems will be required to initiate routine monitoring programs. The total annual national cost for monitoring will range from $17 million to $36 million, approximately $12 million to $25 million of which will be spent by community systems.

Costs for additional monitoring will be incurred by those systems exceeding Maximum Contaminant Levels (MCL). The three-year total of these costs is projected to be between $1 million and $3 million.

Should proper system management not be sufficient to bring contaminant levels below the MCL, water treatment will be required. The investment cost of treatment for all systems in violation of MCL is estimated to be between $1.1 billion and $1.8 billion. Community systems will be spending about 98 percent of this total. Treatment costs per system will vary with system size as well as with type of treatment required.

4.1 Routine Monitoring Costs

Routine monitoring costs will be incurred in differing degrees by both community and non-community systems, since there are different monitoring requirements for each type of system. Furthermore, community systems must begin routine monitoring within 18 months after the promulgation of the regulations; non-community systems have an additional 24 months before they must begin monitoring.

4.1.1 Community Water Systems

Routine monitoring requirements for community systems have been set forth in the Interim Primary Drinking Water Regulations. These regulations, as summarized in Table 4-1,

TABLE 4-1

SUMMARY OF ROUTINE MONITORING REQUIREMENTS (EXCEPT TURBIDITY)

SUBSTANCE	MAXIMUM LEVEL	REFERENCE METHOD	MONITORING FREQUENCY
Arsenic	0.05	EPA 1974 p. 95-96	Community system supplied by surface water: initial tests to be performed within one year and repeated at yearly intervals. Community system supplied by groundwater: initial tests within two years, then repeated at three year intervals. Non-community systems will only test for nitrate. Initial tests shall be completed within two years and repeated at intervals determined by the state.
Barium	1.0	SMWW §129	
Cadmium	0.010	SMWW §129	
Chromium	0.05	SMWW §129	
Lead	0.05	SMWW §129	
Mercury	0.002	EPA 1974 p. 118-26	
Nitrate	10.	SMWW §213	
Selenium	0.01	EPA 1974 p. 145	
Silver	0.05	SMWW §129	
Fluoride	1.4 - 2.4	SMWW §121B	
Endrin	0.0002	EPA 1973A	Community systems supplied by surface water; initial test within one year, then repeated at intervals determined by the state, but no less frequently than at three year intervals. Community systems supplied by groundwater; analysis shall be completed by those systems specified by the state.
Lindane	0.004		
Methoxychlor	0.1		
Toxaphene	0.005		
2,4-D	0.1	EPA 1973B	
2,4,5-TP Silvex	0.01		
Coliform (Membrane filter)	Av. 1 per 100 ml Max. 4 per 100 ml	SMWW §408	Number of samples to be tested per month based on number of customers served. Either membrane filter or fermentation tube technique may be used. Community systems supplied by groundwater; state may reduce sampling to not less than one sample per quarter.
Coliform (Fermentation tube)	Max. 10% pos.: 10 ml samples Max. 60% pos.: 100 ml samples	SMWW §407	
Coliform (Residual chlorine)	Min. 0.2 mg/l	SMWW §114G	Daily or more frequent (depending on number of customers served) if substituted for either of the direct coliform methods.

Abbreviations for references:

JAWWA = Journal of the American Water Works Association.
SMWW = Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971.
EPA 1974 = Methods for Chemical Analysis of Water and Wastes, EPA, Office of Technology Transfer, Washington, D.C., 1974.
EPA 1973A = "Method for Organochlorine Pesticides in Industrial Effluents," MDQARL, EPA, Cincinnati, November 1973.
EPA 1973B = "Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," MDQARL, EPA, Cincinnati, November 1973.

show that monitoring requirements vary with the water source and population served by the various systems. The distribution of systems with respect to population served and water source is displayed in Table 4-2. It can be seen from Table 4-2 that most of the systems are small and utilize groundwater sources. Over half serve less than 500 persons. These smaller groundwater systems will require less monitoring than their large surface source counterparts, although their per capita costs will be somewhat higher since there are economies of scale in doing large amounts of sampling.

In developing national monitoring cost estimates, the number of systems requiring routine monitoring is fixed by the number of ground- and surface-water supply systems in each discrete size range (Table 4-2) and the monitoring frequency prescribed by the regulations (Table 4-1). Therefore, the only variable in the cost development is the price per analysis. This price is dependent on the institutional monitoring arrangements made by each system. In this study, the lower monitoring cost is represented by the cost which EPA would incur in its laboratories, and the higher monitoring cost was calculated from the cost which would be charged by moderately expensive commercial laboratories. These monitoring costs are displayed in Table 4-3. The projection of national routine monitoring costs is displayed in Table 4-4.

The analysis of monitoring costs shows that systems serving small populations vastly outnumber larger systems, and therefore assume the greatest share of monitoring costs, while serving a very small percentage of the population. Figure 4-1 shows that 50 percent of the monitoring costs will be borne by approximately 12 percent of the population.

The total monitoring costs shown in Table 4-4 do not reflect the true impact of the imposition of the Interim Primary Drinking Water Regulations, since much monitoring is presently being done under the Public Health Service Act and under existing state monitoring laws.

A review was made of those interstate water systems which are also community water systems and are therefore currently subject to Federal purview under the interstate quarantine regulations of the Public Health Act. The populations served and water sources of these systems are shown in Table 4-5. However, an analysis of the monitoring practices of these systems shows that only the coliform measurements are taken at a rate commensurate with the

TABLE 4-2

DISTRIBUTION OF COMMUNITY WATER SYSTEMS BY POPULATION CLASS AND SOURCE OF WATER[a]

POPULATION	SOURCE OF WATER (NO. OF SYSTEMS) SURFACE	GROUND	MIXED	PURCHASED	TOTAL NUMBER OF SYSTEMS	POPULATION SERVED	PER CAPITA DAILY PRODUCTION (GAL.)[b]
25-99	275	6,361	56	316	7,008	420,500	99
100-499	946	12,947	199	1,021	15,113	3,778,250	109
500-999	548	4,278	144	422	5,392	3,774,400	118
1,000-2,499	857	3,690	281	354	5,182	7,773,000	132
2,500-4,999	625	1,607	189	184	2,605	8,857,000	140
5,000-9,999	468	1,079	169	142	1,858	12,634,400	154
10,000-99,999	767	1,243	274	315	2,599	61,423,400	158
100,000-999,999	108	63	52	13	236	57,277,200	174
≥1,000,000	5	0	2	0	7	21,523,600	192
TOTAL	4,599	31,268	1,366	2,767	40,000	177,470,750	165

[a] Based on EPA Survey of Community Water Supplies, as of July 1975.

[b] There are 0.00378 m^3 per gallon.

TABLE 4-3

ANALYSIS OF DRINKING WATER SAMPLES: TYPICAL CHARGES BY COMMERCIAL LABORATORIES AND EPA FOR ANALYSES SPECIFIED IN THE REGULATIONS

LABORATORY: LOCATION (STATE):	A RI ($)	B[a] FL ($)	C MA ($)	D MA ($)	E[b] NJ ($)	F[c] NM ($)	G NJ ($)	COMMERCIAL RANGE ($)	EPA RATE ($)
Gross Alpha and Beta	-	-	-	15	-	20	12	12-20	
Strontium-89 and 90	-	-	-	-	-	80	45	45-80	
Tritium	-	-	-	-	-	15-20	10	10-20	
Iodine-131	-	-	-	-	-	65			
Cesium-134 and 137	-	-	-	-	-	55, 80	65	65-155	
Potassium-40	-	-	-	-	-	10			
Coliform (Membrane filter)	20	10	20	15, 10, 8[d]	-	-	-	8-20	5
(Fermentation tube)	20	-	-	20, 15, 10[d]	-	-	-	10-20	
Chlorinated Hydrocarbons		45[e]	40	75	75, 125[f]	-	-	40-305	150
Organophosphates	210	45[e]	40	-75	75, 125[f]	-	-	40-180	
Chlorophenoxys		45[e]	40	-75	75, 100[f]	-	-	40-80	
Arsenic	28	20	12-20	15, 10[g]	40	-	-	10-40	7.75
Barium	15	10	12-20	15, 10[g]	15	-	-	10-20	7.75
Cadmium	10	15	12-20	15, 10[g]	15	-	-	10-20	7.75
Chromium	10	10	12-20	15, 10[g]	15	-	-	10-20	5.60
Lead	10	10	12-20	15, 10[g]	15	-	-	10-20	5.60
Mercury	20	15	12-20	20, 15[g]	40	-	-	12-40	11.55
Nitrate	10	5	15-25	15, 12.50[g]	23	-	-	5-25	5.60
Selenium	55	20	12-20	15, 10[g]	40	-	-	10-55	7.75
Silver	10	15	12-20	15, 10[g]	15	-	-	10-20	5.60
Fluoride	12	15	15-25	10, 8[g]	23	-	-	8-25	5.60
Inorganics - All Components	195	155	150-250	185, 120.50[g]	276	-	-	120-276	70.00

[a] A 5 percent discount on bills over $500.
A 10 percent discount on bills over $1,000.
A 15 percent discount on bills over $1,500.

[b] A 30 percent discount for six or more samples.

[c] Up to 20 percent discount available.

[d] Highest price is for single sample; middle for 2-10 samples; lowest for 11 or more samples.

[e] Price for scan plus one component analysis. Price for each additional component is $45.

[f] Higher price is for full analysis; lower price is for analysis of one specified component.

[g] Higher price is for single sample; lower for 2-10 samples.

TABLE 4-4

COSTS OF ROUTINE MONITORING FOR THE COMMUNITY WATER SYSTEMS

COMPONENT	SYSTEM TYPE		DEADLINE FOR INITIAL TESTING	SUBSEQUENT TEST INTERVALS	NUMBER OF SYSTEMS	ASSUMED COST PER TEST	NUMBER OF TESTS (N) AND COSTS ($ MILLION) PER YEAR					
							FIRST YEAR		SECOND YEAR		THIRD & SUBSEQUENT YEARS	
							N	$ MILLION	N	$ MILLION	N	$ MILLION
Inorganics	Surface		1 yr.	1 yr.	5,965	$70-170	5,965		5,965		5,965	
	Ground		2 yr.	3 yr.	31,268	$70-170	15,634		15,634		10,423	
	Master Meter		1 yr.	1 yr.	2,767	$70-170	2,767		2,767		2,767	
INORGANICS TOTAL					40,000		24,366	1.7-4.1	24,366	1.7-4.1	19,154	1.3-3.2
Organics	Surface		1 yr.	3 yr.	5,965	$150-260	5,965		5,965		1,988	
	Ground				31,268	$150-260	0		0		0	
	Master Meter		1 yr.	3 yr.	2,767	$150-260	2,767		2,767		922	
ORGANICS TOTAL					40,000		8,732	1.3-2.3	8,732	1.3-2.3	2,910	0.4-0.8
Coliform	25-1,000			1/mo.	27,513	5-10	330,156		330,156		330,156	
	1,000-2,499			2/mo.	5,182	$ 5-10	124,368		124,368		124,368	
	2,500-4,999	Average 3,500		4/mo.	2,605	$ 5-10	125,040		125,040		125,040	
	5,000-9,999	" 6,800		8/mo.	1,858	$ 5-10	178,368		178,368		178,368	
	10,000-24,999	" 15,200		17/mo.	1,597	$ 5-10	325,788		325,788		325,788	
	25,000-49,999	" 34,300		40/mo.	677	$ 5-10	324,960		324,960		324,960	
	50,000-99,999	" 68,200		75/mo.	339	$ 5-10	305,100		305,100		305,100	
	100,000-249,999	" 148,600		120/mo.	155	$ 5-10	223,200		223,200		223,200	
	250,000-499,999	" 350,100		180/mo.	43	$ 5-10	92,800		92,800		92,800	
	500,000-999,999	" 735,000		260/mo.	24	$ 5-10	74,880		74,880		74,880	
	Over 1,000,000	" 3,074,800		450/mo.	7	$ 5-10	37,800		37,800		37,800	
COLIFORM TOTAL					40,000		2,142,460	10.7-21.4	2,142,460	10.7-21.4	2,142,460	10.7-21.4
TOTAL PROJECTED MONITORING COSTS: 40,000 SYSTEMS								13.7-27.8		13.7-27.8		12.4-25.4

ASSUMPTIONS:

1. Additional tests not included for substances found to exceed 50 percent, 75 percent or 100 percent of allowed standard limits.
2. Turbidity monitoring not included.
3. No allowance for the use of residual chlorine tests as substitute for coliform tests.
4. Costs based on commercial rates.
5. Coliform sampling frequency estimated from average size of works in each population chart.
6. For initial deadlines and test intervals greater than one year, costs are spread eveny throughout interval.
7. Includes mixed systems.

TABLE 4-5

INTERSTATE CARRIER WATER SYSTEMS WHICH ARE ALSO COMMUNITY WATER SYSTEMS

POPULATION	SOURCE OF WATER				TOTAL NUMBER OF SYSTEMS
	SURFACE	GROUND	MIXED	PURCHASED	
25-99	1	5	0	0	6
100-499	1	11	1	0	13
500-999	4	5	0	2	11
1,000-2,499	6	11	2	0	19
2,500-4,999	10	11	3	3	27
5,000-9,999	25	17	6	3	51
10,000-99,999	138	67	47	24	276
100,000-999,999	86	35	42	3	166
>1,000,000	5	0	2	0	7
TOTAL	276	162	103	35	576

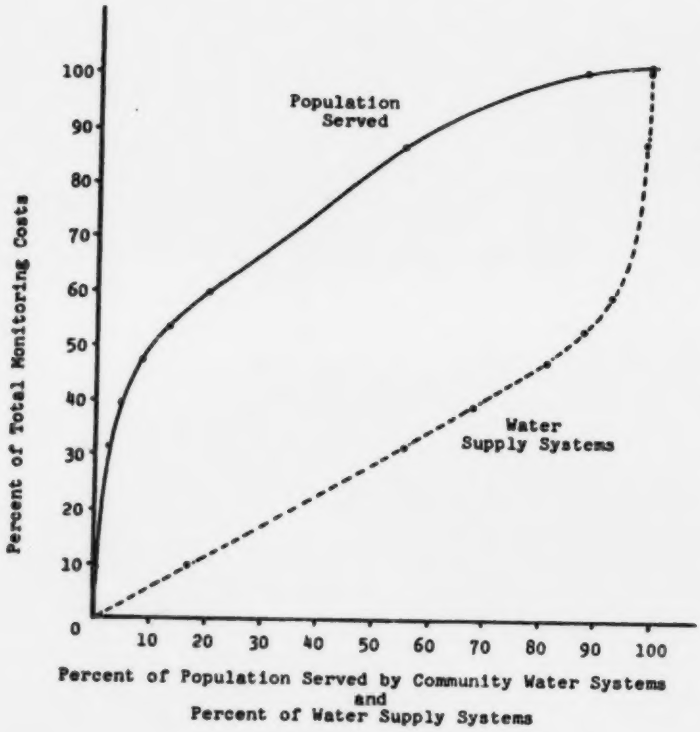

Figure 4-1. This figure shows the percentages of total monitoring costs in the United States versus the percentages of population served and the percentages of the water supply systems.

Interim Primary Drinking Water Regulations. Other aspects of the regulations, such as potential inorganic contaminants, are not subject to control under the Public Health Act.

The estimated costs of the routine coliform measurements currently being performed are shown in Table 4-6. The results of this table show that between $7 million and $14 million of the monitoring costs estimated in Table 4-4 are already performed. These current monitoring costs account for approximately 50 percent of the total estimated monitoring costs to community systems. Therefore, the actual incremental costs of the regulations to community systems are between $6.7 million and $13.8 million for each of the first two years. The number of tests to be performed for the non-interstate carrier systems is 44 percent of the total number of expected analyses.

TABLE 4-6

PRESENT COSTS FOR COLIFORM MONITORING OF INTERSTATE CARRIER WATER SYSTEMS

				NUMBER OF INTERSTATE SYSTEMS	NUMBER OF TESTS	COST PER YEAR ($ million)
COLIFORM:	25-99 persons	Average	47	6	144	
	100-499	"	178	13	312	
	500-999	"	604	11	264	
	1,000-2,499	"	1,741	19	456	
	2,500-4,999	"	4,258	27	1,620	
	5,000-9,999	"	6,413	51	4,284	
	10,000-99,999	"	43,349	276	165,600	
	100,000-999,999	"	449,528	166	398,400	
	> 1,000,000	"	3,074,800	7	37,800	
COLIFORM TOTAL FOR 576 INTERSTATE SYSTEMS					608,880	3.0-6.1
COLIFORM TOTAL FOR 39,424 NON-INTERSTATE SYSTEMS					842,545	4.3-8.3
TOTAL PRESENT COLIFORM MONITORING FOR 40,000 SYSTEMS						7.3-14.4

4.1.2 Non-Community Water Systems

There are approximately 200,000 non-community systems which will be required to perform routine monitoring. It is assumed that no system will shut down as an alternative to routine monitoring. The cost figures for the individual tests are the same as those used to estimate routine monitoring costs for community systems. Table 4-7 shows the total number of public non-community systems broken down by source. The costs for routine monitoring are shown in Table 4-8.

It is estimated that at present no more than 30 percent of the required coliform testing is being performed. Since this amounts to between $1.2 million and $2.4 million per year, the projected total additional national monitoring costs are between $3.35 million and $6.95 million for non-community systems for the first two years of compliance.

4.2 Special Monitoring Costs Due to Exceeding Maximum Contaminant Level

Should the routine monitoring program turn up a violation of an MCL, additional monitoring will be required. This incremental monitoring will serve to determine whether the problem is chronic or only a sampling anomaly.

The special monitoring procedures mandated by the Interim Primary Drinking Water Regulations are outlined in Table 4-9. The costs for this additional monitoring are discussed both for community and non-community systems. It is estimated that the special monitoring costs will be incurred during the first two years of compliance for each type of system.

4.2.1 Community Water Systems

The costs of the additional testing due to MCL violations are the same per test as those for routine monitoring. The additional national cost of monitoring is dependent upon the number and type of MCL violations.

Although the ongoing EPA inventory of community systems is taken to be representative of the population of supply systems in the country, this data base lacks water quality

TABLE 4-7

NUMBER OF NON-COMMUNITY WATER SYSTEMS BY SOURCE

	SURFACE WATER	GROUNDWATER
ALABAMA		
ALASKA	N	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	N	N
COLORADO	N	95
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	100
HAWAII	N	N
IDAHO	175	878
ILLINOIS	100	4,500
INDIANA	N	10,000
IOWA	N	N
KANSAS	20	1,200
KENTUCKY	N	N
LOUISIANA		
MAINE	N	N
MARYLAND	2	4,100
MASSACHUSETTS	N	N
MICHIGAN	10	16,000
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	N
NEVADA		
NEW HAMPSHIRE	N	
NEW JERSEY	N	N
NEW MEXICO	N	N
NEW YORK	N	N
NORTH CAROLINA	N	N
NORTH DAKOTA	N	N
OHIO	100	19,000
OKLAHOMA	0	4,000
OREGON		
PENNSYLVANIA	0	11,800
RHODE ISLAND	N	N
SOUTH CAROLINA	25	1,353
SOUTH DAKOTA	2	600
TENNESSEE		
TEXAS	150	10,000
UTAH	5	500
VERMONT	100	3,000
VIRGINIA	0	9,400
WASHINGTON	50	2,000
WEST VIRGINIA	N	200
WISCONSIN		
WYOMING	16	410
TOTALS	758	99,136

N is not known.
No entry indicates lack of response.

TABLE 4-8

ROUTINE MONITORING COSTS FOR NON-COMMUNITY WATER SYSTEMS[a]

	CONTAMINANT		PER SYSTEM	NATIONWIDE COSTS
	NITRATE	COLIFORM	($)	($ million)
Deadline for Initial Testing	2 years	None		
Subsequent Test Intervals	6 years[b]	1 per quarter		
Assumed Cost Per Test ($)	5.50 - 13.50	5 - 10		
Cost Per Year				
First 2 Years ($)	2.75 - 6.75	20 - 40	22.75 - 46.75	4.55 - 9.35
Subsequent Years ($)	0.92 - 2.25	20 - 40	20.92 - 42.25	4.18 - 8.45

[a] Effective within two years of effective date of regulations.

[b] At state discretion (six years assumed to be reasonable).

TABLE 4-9

MONITORING REQUIREMENTS WHEN MAXIMUM CONTAMINANT LEVEL IS EXCEEDED

CONTAMINANT	MANDATED MONITORING REQUIREMENTS
COLIFORM[a]	Collect and analyze at least two daily samples from same sampling location where violation occurred until at least two consecutive samples show no positive coliform results.
INORGANIC AND ORGANIC CHEMICALS[b]	Initiate three additional analyses within one month. If average of four samples exceeds MCL, State shall determine monitoring frequency.
NITRATE[a]	Repeat the analysis within 24 hours of initial analysis. If mean of two samples exceeds MCL, additional monitoring at state discretion.

[a] Applies to both community and non-community systems.

[b] Applies to community systems only.

data necessary to estimate MCL violations. Therefore, the water quality data base developed in the 1969 CWSS study was used to evaluate the impact of implementing the Interim Primary Drinking Water Regulations. (It was necessary to supplement the CWSS study with information from the EPA Interstate Carrier Study and 10 EPA-State evaluations to obtain data on mercury violations, which are not considered in the CWSS survey.[1]) Table 4-10 gives a summary of the water quality data presently available on community water supply systems.[2]

Table 4-11 displays the number of MCL violations by type according to data from the CWSS by plant population served. Almost 90 percent of those systems in violation served fewer than 5,000 people. The special monitoring costs which would result from applying these violation data to the EPA inventory sample are displayed in Table 4-12. The estimated total of these costs is between $0.27 million and $1.34 million.

4.2.2 Non-Community Water Systems

The data on violations used in this analysis were developed from 11 separate studies of Federal and state "semi-public" water supply systems which serve the travelling public. Using these studies to extrapolate national cost figures is very difficult, since these Federal systems often have more treatment facilities than non-Federal systems. In addition, these systems are not representative of the national distribution of water by source. Table 4-13 lists the number of systems which exceeded one or more maximum contaminant levels for public non-community systems, while Table 4-14 shows the costs of monitoring these systems for coliform and nitrate violations. This table shows that the total special monitoring costs for non-community systems is estimated to be between $0.4 million and $1.9 million.

4.3 Total Monitoring Costs

The 40,000 community systems will bear all the monitoring costs for the first two years. Table 4-15 shows that almost all of these costs will be for routine monitoring. The 200,000 public non-community systems will not have to do any

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[1] U.S. Department of Health, Education and Welfare, Public Health Service: Bureau of Hygiene, Environmental Health Service, "Community Water Supply Study -- Analysis of National Survey Findings," July 1970 and data base therein.

[2] The subject of water quality data will be examined in greater detail in Section 4.4

TABLE 4-10

SUMMARY OF WATER QUALITY DATA AVAILABLE FOR COMMUNITY WATER SYSTEMS

	1969 CWSS STUDY				1975 EPA INTERSTATE CARRIER STUDY		10 EPA-STATE STUDIES	
CONTAMINANT	# OF SURFACE SYSTEMS ANALYZED	% OF SURFACE SYSTEMS TESTED IN VIOLATION	# OF GROUNDWATER SYSTEMS ANALYZED	% OF GROUNDWATER SYSTEMS TESTED IN VIOLATION	# OF SYSTEMS ANALYZED	% OF SYSTEMS IN VIOLATION	# OF SYSTEMS ANALYZED	% OF SYSTEMS IN VIOLATION
Arsenic	228	0	710	0.42	544	0	252	0
Barium[a]	4	0	37	2.7	502	0	147	0.7
Cadmium	233	0	714	0.56	587	0	294	0.7
Chromium	233	0	714	0.42	596	0	294	0.5
Lead	233	0.43	714	2.10	591	0.3	295	1.9
Mercury	-	-	-	-	474	2.7	289	1.9
Nitrate	228	0	710	3.1	640	0	249	0.4
Selenium	227	0.44	707	1.13	-	0.24	250	2.1
Silver	233	0	714	0	483	0	294	0
Fluoride	233	0	714	5.0			189	6.3

[a] Barium was not analyzed in 677 additional groundwater systems since they had ≥2 mg/1 $SO_4^=$ making the presence of soluble Ba unlikely.

TABLE 4-11

NUMBER OF COMMUNITY WATER SYSTEMS WHICH EXCEEDED ONE OR MORE MAXIMUM CONTAMINANT LEVEL BROKEN DOWN BY POPULATION SERVED[a]

POPULATION SERVED	As	Ba	Cd	Cr	Pb	NO_3	Se	Ag	F
25-99	0	0	0	2	4	5	2	0	5
100-499	1	0	2	0	6	8	5	0	18
500-999	2	0	0	0	1	1	1	0	3
1,000-2,499	0	1	1	0	3	2	0	0	3
2,500-4,999	0	0	1	1	0	1	1	0	2
5,000-9,999	0	0	0	0	2	3	0	0	4
10,000-99,999	0	0	0	0	0	1	0	0	1
100,000-999,999	0	0	0	0	0	1	0	0	0
>1,000,000	0	0	0	0	0	0	0	0	0
TOTAL	3	1	4	3	16	22	9	0	36

[a] From CWSS study.

TABLE 4-12

SPECIAL MONITORING COSTS FOR COMMUNITY WATER SYSTEMS WHICH EXCEEDED A MAXIMUM CONTAMINANT LEVEL

Contaminant	Percent of CWSS Systems Exceeding MCL[a]	Number of Systems Projected to be in Violation[b]	Number of Tests Required (1 Year)[c]	Cost Per Test[d] ($)	Total Cost ($ thousand)
Arsenic	0.42G	131	3-6	7.7-18.5	3.0-14.6
Barium	0.14G	44	3-6	7.7-18.5	1.0-4.8
Cadmium	0.56G	175	3-6	7.7-18.5	4.0-19.4
Chromium	0.42G	131	3-6	5.6-13.5	2.2-10.6
Lead	0.43G 2.10S	227	3-6	5.6-13.5	3.8-18.4
Mercury[e]	1.35G 1.35S	483	3-6	11.6-28.0	16.8-81.2
Nitrate	3.10G	969	3-6	5.6-13.5	16.3-78.4
Selenium	1.13G 0.44S	373	3-6	7.7-18.5	8.6-41.4
Silver	0	0	3-6	5.6-13.5	0
Fluoride	5.00G	1,563	3-6	5.6-13.5	26.3-126.6
Coliform	0.88[f]	18,853[f]	2-5	5.0-10.0	188.5-942.7
TOTAL FOR 40,000 SYSTEMS, NATIONWIDE[b,d]					270.5-1,338.1

[a] In CWSS sample of 969 systems based on surface (S) or groundwater (G) source.

[b] Projected from CWSS data base by source of water.

[c] Additional tests may be required at state discretion.

[d] Low cost based on EPA laboratory rates, high cost based on commercial rates.

[e] No data in CWSS -- Number estimated from interstate carrier and other state data.

[f] Samples in violation.

TABLE 4-13

NUMBER OF PUBLIC NON-COMMUNITY WATER SYSTEMS WHICH EXCEEDED ONE OR MORE MAXIMUM CONTAMINANT LEVEL*

STUDY	CONTAMINANT								
	Ag	NO_3	CR	Coliform	Se	F	Pb	Hg	Cd
Bureau of Reclamation[a]	0	4	1	7	6	0	0	0	0
Water Resource[b]	0	0	0	14	0	0	0	0	0
Interstate[c]	0	3	0	18	1	1	1	0	0
Park Service[d]	0	0	0	4	0	5	1	2	0
Forest Service[e]	1	0	0	24	0	11	0	0	0
Kansas[f]	0	2	0	9	1	1	4	0	0
Florida[g]	0	0	0	2	0	0	0	0	0
Kentucky[h]	0	0	0	21	0	0	1	0	0
Tennessee[i]	0	0	0	12	0	0	0	0	0
Georgia[j]	0	0	0	10	0	0	4	0	3
Wyoming[k]	0	0	0	4	0	0	0	0	0
TOTAL	1	9	1	125	8	18	11	2	3

*See following page for references.

[a] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems at Bureau of Reclamation Developments, EPA-430/9-73-004, June 1973.

[b] U.S. Environmental Protection Agency, Office of Water Programs, Sanitary Survey Of Drinking Water Systems on Federal Water Resource Developments, A Pilot Study, August 1971.

[c] U.S. Environmental Protection Agency, Water Supply Division, Drinking Water Systems On and Along the National System of Interstate and Defense Highways, A Pilot Study, 1972.

[d] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems in the National Park Service System, EPA-520/9-74-016, December 1974.

[e] U.S. Environmental Protection Agency, Water Supply Division, A Pilot Study of Drinking Water Systems in the U.S. Forest Service System, November 1974.

[f] U.S. Environmental Protection Agency, Region VII, Water Supply Program, Evaluation of the Kansas Water Supply Program, 1972.

[g] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, Evaluation of the Florida Water Supply Program, 1973.

[h] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, Evaluation of the Kentucky Water Supply Program, May 1972.

[i] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, Evaluation of the Tennessee Water Supply Program, January 1971.

[j] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, Evaluation of the Georgia Water Supply Program, July 1973.

[k] U.S. Environmental Protection Agency, Region VIII, Water Supply Branch, Evaluation of the Wyoming Water Supply Program, December 1972.

TABLE 4-14

SPECIAL MONITORING COSTS OF NON-COMMUNITY WATER SYSTEMS WHICH EXCEEDED A MAXIMUM CONTAMINANT LEVEL

COLIFORM	
Tests required per coliform violation	2-5
Estimated cost per test	\$5-\$10
Cost per system in violation	\$10-\$50
Percent of systems in violation in survey (125 of 729)	17.1%
Resultant number of systems estimated to be in violation, nationwide	34,293
Total cost coliform testing, nationwide (\$ million)	\$0.3-\$1.7
NITRATE	
Tests required per NO_3 violation	3
Estimated cost per test	\$5.60-\$13.50
Cost per system in violation	\$16.80-\$40.50
Percent of systems in violation	2.94%
Resultant number of systems estimated to be in violation, nationwide	5,880
Total cost NO_3 testing, nationwide (\$ million)	\$0.1-\$0.2
TOTAL NON-COMMUNITY SPECIAL MONITORING COSTS (\$ MILLION)	\$0.4-\$1.9

TABLE 4-15

TOTAL MONITORING COSTS MANDATED BY THE INTERIM PRIMARY DRINKING WATER REGULATIONS

($ million)

	FIRST YEAR	SECOND YEAR	THIRD YEAR
Cost of Routine Monitoring for the 40,000 Community Systems[a]	13.3 - 27.3	12.7 - 26.3	12.3 - 25.5
Monitoring Due to Violations of MCL for 40,000 Community Systems			
Coliform Violation Monitoring	0.5 - 2.0		
Inorganic Violation Monitoring	0.01 - 0.3	0.01 - 0.3	
Cost of Routine Monitoring for the 200,000 Non-Community Systems[b]			4.5 - 9.4
Monitoring Due to Violations of MCL for 200,000 Non-Community Systems[c]			0.3 - 0.8
TOTAL PROJECTED MONITORING COSTS[d]	13.8 - 29.6	12.7 - 26.6	17.1 - 35.7
PRESENT MONITORING COSTS	[7.3 - 14.4]	[7.3 - 14.4]	[8.5 - 16.8]
TOTAL ADDITIONAL MONITORING COSTS	6.5 - 15.2	5.4 12.2	8.6 - 18.9

[a] Annual costs beginning the first year after implementation of the regulations.

[b] Annual costs beginning the third year after implementation of the regulations.

[c] Total monitoring costs due to violations spread over a 2-year period.

[d] Totals may not add due to rounding.

monitoring until the third year. At that time they will account for approximately 30 percent of the total monitoring costs of $17 million to $36 million. The remaining 70 percent of the costs should be due to the routine monitoring of community systems, since violations in these systems are expected to have been corrected by the third year. Bacteriological monitoring will account for approximately 80 percent of the total monitoring costs.

4.4 Water Quality Data

It is essential that the water quality data used in this analysis be explored in detail before developing treatment costs. This section relates the characteristics of existing water quality data bases to the characteristics of the national water supply systems. In this study, as was mentioned earlier, the EPA projection of 40,000 community water supply systems is assumed to be valid and the ongoing EPA inventory of community systems is taken to be representative of the population of supply systems in the country.

For every organic and inorganic contaminant except mercury, the water quality data developed in the 1969 CWSS study was used to evaluate the impact of implementing the Interim Primary Drinking Water Regulations. However, as was pointed out in Section 4.2.1 above, it was necessary to supplement the CWSS study with information from the EPA Interstate Carrier Study and the 10 EPA-State evaluation studies to obtain data on mercury violations. Table 4-10 gave a summary of the water quality data presently available on community water supply systems. Since all of these water samples were analyzed using the same methodology, the results of these studies should be comparable. If multiple samples were analyzed, the results were averaged to determine if the system was in violation.

There are certain problems inherent in the analyses for the contaminants shown in Table 4-10 which affect their interpretation. Barium was not analyzed if the sulfate concentration was greater than 2 mg/l, which accounts for the smaller number of barium analyses in all three studies. However, if sulfate is found to be present in this concentration in a water supply, it is highly unlikely that barium will be present in a soluble form. It is, therefore, reasonable to use a value of 0.14 percent of systems in violation rather than the 2.7 percent which was based on only 37 samples, since 2.56 percent of the samples have sulfate in the water in sufficient quantity to precipitate out the barium.

Because lead is usually found in the distribution system rather than in the raw water source, it is essential that multiple testing in both source and distribution systems be done for lead contamination. This was not always done in the CWSS study.

Nitrate is mainly a groundwater problem. This is apparent in comparing the percentage of systems exceeding the maximum contaminant level in the CWSS study and the results of the Interstate Carrier Water Study in Table 4-10. Table 4-16 shows that 75.2 percent of the CWSS systems used groundwater sources while only 29.9 percent of the interstate carrier supplies used groundwater.

TABLE 4-16

PERCENT OF COMMUNITY WATER SYSTEMS WHICH UTILIZE EACH OF FOUR SOURCES OF WATER FOR FIVE STUDIES

SOURCE OF WATER	EPA COMMUNITY INVENTORY	1969 CWSS	EPA INTERSTATE CARRIER	10 EPA-STATE STUDIES	1970 AWWA
Ground[a]	78.2	75.2	29.9	60.5	40.0
Surface[b]	11.5	21.6	48.3	32.6	34.7
Mixed[c]	3.4	3.2	15.6	4.3	14.9
Purchased[d]	6.9		6.2	2.5	10.0
TOTAL	100.0	100.0	100.0	99.9	100.0

[a] Includes ground and (ground and purchased).

[b] Includes surface and (surface and purchased).

[c] Includes ground and surface and (ground and surface and purchased).

[d] Includes purchased only.

The data on turbidity in the CWSS study are invalid. To be valid, turbidity sampling should be done in situ, but in the CWSS study the samples were transported to the laboratories, and several days passed between sampling and analysis. Furthermore, the one-time grab samples used are not representative of the seasonal and diurnal variations in turbidity. By their very nature surface systems are likely to exceed the one turbidity unit limit at least part of the year. For this reason it is assumed for the purposes of this study that all systems which use surface water as a source will need to provide some form of clarification if none is presently being used.

Coliform measurements are also a problem since there can be rapid variations in the number of organisms found. The Interim Primary Drinking Water Regulations state that numbers of violations averaged on a monthly or quarterly basis should be used to determine if a system is in violation. This procedure was not followed in the three studies shown in Table 4-10. However, historical data indicate that approximately 27.5 percent of the systems now in operation will need to install some form of disinfection equipment in the future.

Since no analysis for mercury was made in the 1969 CWSS study, it was necessary to utilize the values found in the Chemical Analysis of the Interstate Carrier Water Supply Systems and the 10 state evaluations to estimate the percentage of systems which would exceed the maximum level of this contaminant. A value of 2.7 percent was chosen by dividing the total number of samples analyzed in the interstate carrier and state evaluations by the number of samples which exceeded the maximum contaminant levels.

4.4.1 Expansion Factors

Since the CWSS data base for which the water quality data exist represents a different population (Table 4-17) by source of water and population served than does the EPA inventory (Table 4-18), it is necessary to apply expansion factors in order to project national treatment costs from this small sample.

The national treatment costs were determined by multiplying the percent of MCL exceeders (categorized by source of water for each contaminant) by the number of systems in each of nine size categories. The number of plants found in this manner was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE 4-17

BREAKDOWN OF 1969 CWSS STUDY BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	SOURCE OF WATER			
	GROUND	SURFACE	MIXED	TOTAL
25-99	10.7	1.2	0.2	12.1
100-499	26.9	3.8	0.4	31.1
500-999	8.0	2.8	0.4	11.2
1,000-2,499	8.9	4.8	0.5	14.2
2,500-4,999	5.7	2.4	0.6	8.7
5,000-9,999	6.2	2.2	0.2	8.6
10,000-99,999	7.8	3.1	0.6	11.5
100,000-999,999	1.0	1.2	0.3	2.5
> 1,000,000	0[a]	0.1	0	0.1
TOTAL	75.2	21.6	3.2	100.0

[a] Zero (0) means less than 0.1 percent.

TABLE 4-18

BREAKDOWN OF EPA COMMUNITY WATER SYSTEM INVENTORY BY POPULATION SERVED AND SOURCE OF WATER[a]

POPULATION SERVED	SOURCE OF WATER				
	GROUND	SURFACE	MIXED	PURCHASED	TOTAL
25-99	15.9	0.7	0	0.8	17.4
100-499	32.4	2.4	0.5	2.5	37.8
500-999	10.7	1.4	0.4	1.1	13.6
1,000-2,499	9.2	2.1	0.8	0.8	12.9
2,500-4,999	4.0	1.6	0.5	0.5	6.6
5,000-9,999	2.7	1.1	0.4	0.4	4.6
10,000-99,999	3.1	1.9	0.7	0.8	6.5
100,000-999,999	0.2	0.3	0.1	0	0.6
>1,000,000	0[b]	0	0	0	0
TOTAL	78.2	11.5	3.4	6.9	100.0

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[a] As of July 1975.

[b] Zero (0) means less than 0.1 percent.

4.5 Treatment Costs Incurred by Community Water Systems

The costs incurred by a community in removing any contaminant are site-specific and are dependent on many exogenous factors, such as treatment facilities present, age of system, availability of alternate sources of water, and many other interrelated problems. A theoretical discussion of the chemistry involved in contaminant removal can be found in Appendix D. Since each system is a separate entity, a methodology has to be devised for using the CWSS data base of 969 plants in developing the national cost estimates for treatment required by the regulations.

Those systems having problems with a particular contaminant are assigned capital and O&M costs for correcting the violation. Lead treatment costs are determined using pH control as the treatment process; ion exchange is the treatment process chosen to treat for Cd, Cr, NO_3, Se, Hg, and Ba. Activated alumina adsorption is chosen to remove excess fluoride and arsenic. (All cost functions utilized in forming capital and O&M costs can be found in Appendix E).

A cost estimate is made to determine the capital and annual O&M costs to clarify those water systems in the EPA inventory of 40,000 systems which have surface-water supplies and do not clarify. The annual and capital costs are determined by assuming that direct filtration will be used to clarify those systems in which clarification is necessary.

In developing capital and O&M costs for disinfection, it is assumed that 27.5 percent of the systems which do not presently chlorinate will need to install chlorination equipment to meet the coliform regulation.

If a system had an inorganic violation in the CWSS study, but nonetheless had the correct remedial treatment process, the violation is attributed to system malfunction and it is considered unnecessary to calculate additional capital expenses.

The cost descriptions used are divided into two main categories. The first category is that of cost functions and estimates for water supply systems with production greater than 1,000 m^3/day (264,000 gpd). The second category describes the corresponding costs for small systems. There is a need for such a distinction because the costs developed for large supply systems are not valid for systems of smaller capacity. Consequently, different sets of functions are devised for the following processes: (1) clarification (consisting of direct filtration), (2) chlorination, (3) ion exchange, (4) pH control, and (5) activated alumina.

The assumptions used in developing costs are:

1. The quantity of water production can be estimated by using the appropriate production figures for each population category (Table 4-2);
2. Electricity costs 3 cents per kilowatt-hour;
3. Land costs $202 per hectare;
4. Capital costs include expenses for equipment purchase, installation, construction, design, engineering study, land, site development and construction overhead. Operating and maintenance costs include labor, supplies, materials, chemicals, electric utility and general maintenance;
5. The interest rate is 7 percent;[1]
6. A 15-year payoff period is assumed.[2]

The cost functions for large water supply systems were generated primarily from the results of a report by D. Volkert & Associates.[3] These functions, which have been compared favorably with another report,[1] are summarized in Appendix E. It should be noted that the cost estimates are for individual processes and that cascading them in series may lead to lower costs. Moreover, these functions are valid only for plant capacities from 1,000 m^3/day (264,000 gpd) to 300,000 m^3/day (79.2 mgd). Unless otherwise specified, these cost estimates are in 1975 dollars.

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[1] Interest rates are quite variable and show considerable fluctuation. Seven percent was the average rate for medium-risk utilities at the time of writing.

[2] This payoff period is considered to be shorter than average for the industry and would cause the results to be on the conservative side.

[3] David Volkert & Associates, Monograph of the Effectiveness and Cost of Water Treatment Processes for Removal of Specific Contaminants, Vol. 1, Technical Manual (Bethesda, Maryland: David Volkert & Associates, 1974).

Cost information for systems producing under 1,000 m^3/day was obtained through (1) personal conversation with several water treatment equipment manufacturers and suppliers and (2) a study of conventional water supply costs conducted by Control Systems Research, Inc. for the Office of Saline Water, U.S. Department of the Interior.[2]

The approach used when cost information was requested from vendors included the following two steps. First, each manufacturer or supplier was queried as to the exact nature of his business. This allowed the cost data obtained to be qualified in terms of actual type of equipment and services supplied for a stated price. The various business functions of the vendors contacted included suppliers of $40 cartridge filter products for home use, manufacturers of treatment unit "packages" for commercial/industrial use, suppliers of complete clarification systems for small municipal systems and/or industrial use, and suppliers of treatment systems designed to handle site-specific problems.

Secondly, each vendor was asked to provide general cost information (capital, installation, operation/maintenance) for equipment customarily used in water treatment application within the flow rate range of interest. It is acknowledged that facilities and equipment provided in a given application are determined from several factors including: (1) raw water quality, (2) desired product water quality, (3) flow rate, (4) existing facilities, (5) systems and equipment flexibility, (6) operation and maintenance needs of equipment, and other site-specific characteristics. Responses were therefore based on either equipment catalogue costs or on actual vendor experience in providing goods and equipment for small systems.

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[1] I.C. Watson, Resource Studies Group, Control Systems Research Inc. (CSR), Manual for Calculation of Conventional Water Treatment Costs (Washington, D.C.: Office of Saline Water, U.S. Department of the Interior, March 1972). Control Systems Research Inc. is now known as KAPPA Systems Inc., Arlington, Virginia.

[2] Watson, Manual for Treatment Costs, 1972.

The information received from vendors was supplemented with cost data contained in the aforementioned CSR study, which is also based largely on equipment cost information provided by vendors. The CSR report was prepared with an emphasis on developing cost curves for systems used in municipal applications and was designed to provide a means for estimating the costs of conventional treatment systems for individual unit operations. Cost functions derived from CSR data reflect 1972 prices and are therefore multiplied by the appropriate factor in order to present results in 1975 dollars.

It should be pointed out here that the cost curves for small and large systems will not produce a continuous function. The main reason for this is that each set of curves was developed independently and perhaps under differing assumptions. The cost differences that occur at the small and large system breakpoint do not materially affect the overall cost estimates. In any event, it was not within the scope of this project to develop a single continuous function for all system sizes covered by the Act.

However, because of the tremendous range in system size, serving from 25 persons to over 1,000,000 persons, there are several reasons why it may be difficult to develop a continuous function for all systems:

1. Small systems can employ package plants;
2. Small systems generally do not require full-time maintenance;
3. Small system treatment package plants may not require housing facilities.

4.6 National Treatment Costs

Table 4-19 shows the cost of treatment by process for the average plant in each of the nine population categories. The following assumptions were implicit in using these costs to make national treatment cost projections:

1. A system will treat its present supply rather than develop an alternative supply;
2. There are no retrofit and cascading benefits when new treatment processes are added;

TABLE 4-19

MODEL SYSTEMS CAPITAL TREATMENT COSTS FOR NINE POPULATION SERVED GROUPS[a]

POPULATION SERVED	DISINFECTION	CLARIFICATION	ION EXCHANGE	pH CONTROL	ACTIVATED ALUMINA
25-99	690	21,000	41,000	690	2,600
100-499	1,200	30,000	68,000	1,200	6,100
500-999	1,800	41,000	100,000	1,800	12,000
1,000-2,499	2,500	52,000	140,000	2,500	22,000
2,500-4,999	7,500	150,000	470,000	7,500	37,000
5,000-9,999	12,000	270,000	810,000	12,000	60,000
10,000-99,999	30,000	640,000	2,000,000	30,000	130,000
100,000-999,999	210,000	3,400,000	11,000,000	210,000	620,000
>1,000,000	2,300,000	22,000,000	67,000,000	2,300,000	3,300,000

[a] Costs were determined for average production and average size plant in each group based on EPA Community Inventory as of July 1975 (Table 4-2).

3. Advanced treatment is necessary to remove all inorganic chemicals;

4. The inorganic violations found in this 1969 study are truly representative of the national water supply systems;

5. The information on mercury violations found in the chemical analysis of the interstate carrier water systems is representative of the country's water supply systems;

6. Chlorination units will have to be installed in 27.5 percent of the systems which do not presently disinfect their water supplies;

7. All surface water systems will install clarification units if they are not presently in use;

8. The mean-sized plant in each of the nine population ranges was used as a model plant to develop costs;

9. The present average daily production was used to determine treatment plant size.

The national costs of treating contaminants in drinking water are displayed in Table 4-20. The capital costs to treat for mercury and nitrate contaminants and turbidity are expected to account for more than three-fourths of the total capital costs. The major O&M cost items are clarification, nitrate treatment, and mercury treatment, with clarification accounting for over 70 percent of the total.

The O&M and capital costs of treatment for community systems are shown in Figure 4-2. The total capital costs for treatment will be approximately $1.1 billion, while the O&M treatment costs are estimated to be $259 million. The national treatment costs for each contaminant and nine population served categories are shown in Appendix F.

4.7 Treatment Costs for Public Non-Community Systems

Since there are only extremely limited and questionable data available on public non-community water systems, it is impossible to make accurate predictions about the treatment

TABLE 4-20

NATIONAL COSTS OF TREATMENT CONTAMINANTS IN DRINKING WATER ASSUMING TREATMENT OF AVERAGE DAILY PRODUCTION

PROCESS	TREATMENT TECHNIQUE	CAPITAL COSTS ($ million)	ANNUAL O&M ($ million)
Clarification	direct filtration	379.3	188.6
NO_3	ion exchange	215.9	18.1
Chlorination	disinfection	17.0	7.2
Mercury	ion exchange	243.0	20.6
Selenium	ion exchange	86.3	7.2
Cadmium	ion exchange	35.7	3.0
Lead	pH control	2.7	0.1
Fluoride	activated alumina	28.3	10.1
Chromium	ion exchange	28.2	2.4
Barium	ion exchange	10.1	0.8
Arsenic	activated alumina	2.3	0.7
SUBTOTAL COMMUNITY		1,048.8	258.8
SUBTOTAL NON-COMMUNITY		23.6	4.4
TOTAL		1,072.4	263.2

[a] The number of plants affected was calculated by multiplying the percentage of violators in each contaminant category by the total number of systems in each size and source category. The number of plants was then multiplied by the cost of treating the mean-sized plant (based on average daily production) in each size category.

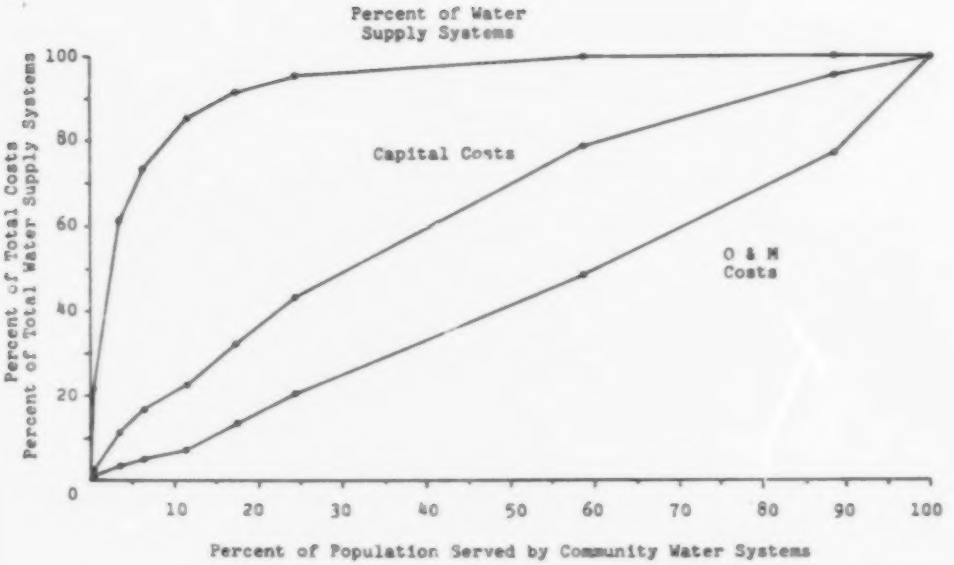

Figure 4-2. This figure shows the percentages of population served by community water systems versus percentages of total treatment costs.

techniques which would be required. It is quite possible that these systems, unlike community systems, would choose to stop supplying water rather than to install any treatment process. However, in this analysis it was assumed that no system will choose to close rather than treat. In the non-community system studies available, 17.1 percent of the systems exceeded the coliform MCL; this means that approximately 34,000 systems nationwide would install disinfection equipment to meet the coliform MCL. It is assumed that these 34,000 systems would install feed hypochlorinators at a capital cost of $400 each, or a national capital cost of $13.6 million. Since the majority of these systems operate for only 3 months of the year, the O&M is assumed to be $100 per year per plant, or a national cost of $3.4 million per year.

The only other major treatment costs encountered by these non-community systems would be for the clarification of surface-water systems. A rapid sand filter can be bought for about $5,000 for a system delivering 20 gallons per minute. It is estimated that less than 1 percent of the non-community systems use surface water as a source (Appendix C, Table C-16). This means that a maximum of 2,000 systems would need clarification, or $10 million in capital investment and an annual O&M cost of $1 million. It is highly doubtful that a non-community water supply system would invest a great deal of capital in extensive treatment systems for inorganic contaminants, although certain systems might invest a few hundred dollars in a simple ion exchange column. In general, it appears that the capital and O&M costs of these non-community systems would be minimal compared to the costs of community systems.

4.8 Sensitivity of Treatment Costs

The following variables were used in developing the capital and O&M requirements for water treatment facilities:

1. Construction costs
2. Site development costs
3. Labor costs
4. Land costs
5. Plant capacity

Each of these variables has an input on the local cost of constructing and running a treatment facility. Table 4-21 shows the regional variations in wages and construction cost indices which were found in March 1975, as well as the national average. In all calculations the national average was used to compute costs, but regional variations can cause a difference of at least 20 percent in costs. Local land costs vary from site to site, but since land costs comprise only a very small percentage of total construction costs, the effect of this variable is minimal.

The major cost factor is plant capacity, since this factor controls the amount of construction and material needed to build a given treatment facility. Water usage may differ markedly among cities having similar populations. For example, Wheeling, West Virginia and Everett, Washington each have water systems serving approximately 65,000 people. Wheeling treats 10 mgd while Everett treats 100 mgd, with the difference in water usage explained by the presence of two pulp plants in Everett. Other factors, such as climate, local economy, urbanization, water distribution facilities, cost to consumer, availability and variability of water

TABLE 4-21

LABOR AND CONSTRUCTION INDICES BY EPA REGION

	I	II	III	IV	V	VI	VII	VIII	IX
March 1975 CPI Index	2,126[a]	2,631	2,374[b]	1,670[c]	2,374	1,679[d]	2,330	1,705	2,309
U.S. Average	2,128	2,128	2,128	2,128	2,128	2,128	2,128	2,128	2,128
Ratio of Regional CPI to U.S. Average CPI	1.02	1.24	1.12	0.78	1.12	0.79	1.09	0.80	1.09
January 1975 BLS Wages[e]	3.96[a]	5.00	4.83[b]	3.50[c]	5.34	4.72[d]	4.48	4.80	5.01
U.S. Average	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71	4.71
Ratio of Regional BLS to U.S. Average BLS	0.84	1.06	1.03	0.74	1.13	1.00	0.95	1.02	1.06
January 1975 Handy-Whitman Index									
Source	385	385	389	389	375	365	371	357	376
Pumping Structure	358	358	377	377	379	364	379	335	378
Pumping Equipment	303	303	303	303	303	303	303	303	303
Plant - large	355	355	386	386	377	354	374	335	357
- small	400	400	380	380	364	355	361	333	351
Distribution Pipes	335	335	338	338	328	324	325	318	322
Building Trades Labor	405	405	421	421	417	387	416	409	411

[a] Based on Boston Index.

[b] Based on Cincinnati Index.

[c] Based on Atlanta Index.

[d] Based on Denver Index.

[e] For manufacturing employees.

sources, and the kinds of commercial and industrial establishments supplied from the municipal system, all determine the quantities of water treated.[1]

The national average water production is presently 165 gallons per consumer day (0.62 m^3/cd), according to the EPA water supply inventory. The production by size category varies from 99 to 192 gpcd (0.38 to 0.73 m^3/cd) (see Table 4-2). A study[2] of 122 private companies (Table 4-22) yields a national average consumption of 146 gpcd (0.55 m^3/cd). This study also indicates that smaller communities can consume considerably less water per consumer than do larger communities. Since production is the most important factor in the price sensitivity analysis, an analysis was performed using peak day demand production. The treatment costs developed for peak day demand and average daily production are shown in Table 4-23. Using peak demand production would put a realistic upper bound on expected treatment costs, since many systems might decide to build treatment capacity to meet the expected maximum demand on the systems, rather than the average daily demand. Building larger treatment plants will not cause O&M rates to go up significantly, however, since most O&M expenses are related to total gallon throughput in the system, regardless of rate of flow.

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[1] Water Resources Council, The Nation's Water Resources (Washington, D.C., 1968), p. 4-1-2.

[2] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities," (Washington, D.C., 1973).

TABLE 4-22

WATER PRODUCTION PER CAPITA PER DAY FOR 122 PRIVATE WATER COMPANIES[a]

NUMBER OF COMPANIES	AVERAGE POPULATION SERVED	GALLONS CONSUMED PER CUSTOMER PER DAY
12	624,339	140
12	239,859	147
41	79,474	162
8	24,885	135
14	11,711	142
28	4,435	119
7	1,166	74
TOTAL 122	23,672	146

[a] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities," Washington, D.C.

TABLE 4-23

NATIONAL COST RANGE FOR TREATMENT OF CONTAMINANTS IN DRINKING WATER

TREATMENT TECHNOLOGY	CONTAMINANT	CAPITAL COSTS[a] ($ million)	ANNUAL O&M ($ million)
Community Systems			
Clarification	Turbidity	379.3 - 682.9	188.6
Chlorination	Coliform	17.0 - 27.4	7.2
Ion Exchange	Ba, Cr, Cd, NO, Hg, Se	619.2 - 996.9	52.1
Activated Alumina	As, Fluoride	30.6 - 52.7	10.8
pH Control	Pb	2.7 - 4.2	0.1
TOTAL		1,048.8 -1,764.1	258.8

[a] Lower bound assumes treatment plant designed for average daily demand; upper bound assumes treatment plant designed for peak daily demand.

CHAPTER FIVE

FEASIBILITY OF FINANCING COSTS

5.0 Introduction

Compliance with the interim regulations will require several types of expenditures by suppliers of drinking water. Monitoring expenses will have to be met in some fashion by all suppliers, while O&M and capital costs for water treatment, as well as the indirect cost of administration will have to be met by those systems exceeding an MCL. This chapter aggregates all costs developed in the previous chapter and explores the financial effect on the impacted systems.

5.1 Present Industry Financial Structure

Although a majority of water systems have debt ratios (ratios of long-term debt to the book value of property) ranging upward from 40 percent, almost one-fourth are free of long-term debt. Approximately 85 percent of these debt-free systems serve communities of less than 5,000 people.[1] However, these debt-free, small systems are not necessarily the most financially sound. Analysis of the income tax returns of water and sanitary systems listed in the Almanac of Business and Industrial Financial Ratios (1975 edition)[2] shows that almost half of the small investor-owned systems failed to show a positive net income (Table 5-1). Many larger water utilities that appear to be saddled with high debt may actually be slightly better off.

Compared with other types of utilities, water systems tend to have high debt ratios. This is not surprising, given the large capital expenditures required in comparison to the low product cost of water. Since many areas have statutory

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[1] R.C. Hyle, "Rate Philosophy," JAWWA 63, (11): 686, November 1971.

[2] Almanac of Business and Industrial Financial Ratios (1975 Edition) (Englewood Cliffs, New Jersey: Prentice-Hall Publishing Company). Data gathered by Prof. Leo Troy, Rutgers University.

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TABLE 5-1

FINANCIAL STRUCTURE OF INVESTOR-OWNED WATER SYSTEMS AND RELATED SERVICES[a]

SIZE OF ASSETS		NUMBER OF FIRMS	NUMBER REPORTING NET LOSS	NET PROFIT BEFORE TAX AS PERCENT OF SALES
A	TOTAL	6,649	2,820	5.4
B	Under $100	4,472	2,160	3.8
C	$100 to $250	1,157	419	2.2
D	$250 to $500	548	133	6.1
E	$500 to $1000	234	39	8.2
F	$1000 to $5000	182	63	Net Loss for Category
G	$5000 to $10,000	19	4	4.5
H	$10,000 to $25,000	17	2	7.5
I	$25,000 to $50,000	6	-	10.8
J	$50,000 to $100,000	8	-	6.5
K	$100,000 to $250,000	5	-	16.3
L	$250,000 and over	1	-	Net Loss for Category

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[a] Almanac of Business and Industrial Financial Ratios (1975 Edition) (Englewood Cliffs, New Jersey: Prentice-Hall Publishing Company, 1975).

limitations on both total indebtedness for public utilities and ceilings on interest rates, some water utilities would be able to absorb only a limited amount of further capital expenditure if it were to be financed by traditional means.

Matters are further complicated by the existence of loan covenants, particularly coverage ratios. Coverage ratios for water utilities are generally defined by the formula:

$$\text{Coverage Ratio} = \frac{\text{Net Revenues}}{\text{Debt Service}}$$

where Debt Service = Interest and Principal Repayments

Unless utilities seeking additional funds are well above their normally required coverage ratios -- which usually range near 1.5[1] -- they may well be forced to finance either with higher interest loans or more expensive common stock (for the investor-owned utilities).

Most utilities, both public and private, finance large capital investments by retaining profits and acquiring debt. Government-owned water utilities usually have access to municipal funds and can sell either general obligation bonds, to be repaid from general revenues (including property taxes), or revenue bonds, which are less secure since they are repaid from water revenues only.

Investor-owned utilities may issue stock as well as bonds, and their credit ratings are more completely dependent on the profitability of their own operations. Unbacked by governmental guarantees and the tax-exempt status of municipal utilities, their debt -- particularly their common stock -- is more risky than the debt issues of government-owned utilities. Since interest rates are proportional to risk, utilities in more secure financial positions can borrow money more easily and at lower interest rates. Government-owned utilities have the advantage that their credit may be more highly rated. At the present time the interest rate on municipal bonds is 4 to 6 percent, while the rate for private (investor-owned) utilities is 6 to 8 percent.[1]

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[1] John D. Wright and Don R. Hassall, "Trends in Water Financing," in Modern Water Rates (8th Edition), edited by Elroy Spitzer (American City Magazine, 1972).

The capital investments required by the new regulations would be financed heavily by new bond issues. For some utilities this will pose no problem; others, already deeply in debt or without the necessary credit ratings, might have difficulty in meeting the new costs. The Safe Drinking Water Act provides for guaranteed Federal loans of up to $50,000 for "small" public water systems, including both public and private utilities. Although the guaranteed loans of $50,000 should ease the transition to full compliance with the interim primary regulations, they may well prove to be insufficient alone, particularly for those systems requiring ion exchange or clarification. Medium-sized water utilities might need more funds and might not be able to obtain the full amounts through bond issues and loans which are not eligible for coverage by the $50,000 loan guarantee provision. One other source of financial aid for these water utilities is the loan and grant program sponsored by the Farmers Home Administration.

In addition to capital investments, other costs would be incurred to meet the more rigorous drinking water regulations; increased monitoring and laboratory analysis of water samples for inorganics, organics, pesticides, and biological contaminants will all add to costs. Although many large water utilities have their own laboratory facilities and personnel for monitoring activities, analyses will have to be performed for more contaminants and more frequently in the future. Many states now provide laboratory services for water analysis at a subsidized price; if state facilities could not be expanded rapidly enough to meet the increased needs, private laboratories might be able to fill the gap. In any case, new equipment would be needed for tests which are not now performed. The water utilities would have to absorb the costs of analysis or pass these costs on to the states through the use of subsidized state and private laboratories.

All increased operating costs for monitoring and for additional treatment, and all increased payments of interest and principal on (new) loans and bonds, would eventually have to be met either directly through increased revenues, or indirectly through funds from state and local tax revenues or from Federal grants (also tax revenues). Private utilities might be able to meet increased operating expenses by retaining more earnings, rather than distributing earnings to investors in the form of dividends; however, this practice would tend to hurt their financial position by decreasing the value of their stock. Hence, it is not an appropriate long-term financial strategy.

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[1] Personal communication -- First National Bank of Boston, April 1975.

Since the major source of revenue for most water utilities is the sale of water to customers, the issue of rates (or prices) is relevant to this discussion of financing. Because they face greater risk and lack tax-exempt status, the investor-owned companies have a higher cost of capital; thus the investor-owned companies generally charge higher rates per unit than do public systems (Figure 5-1). Rates also vary among systems which have different amounts of treatment.

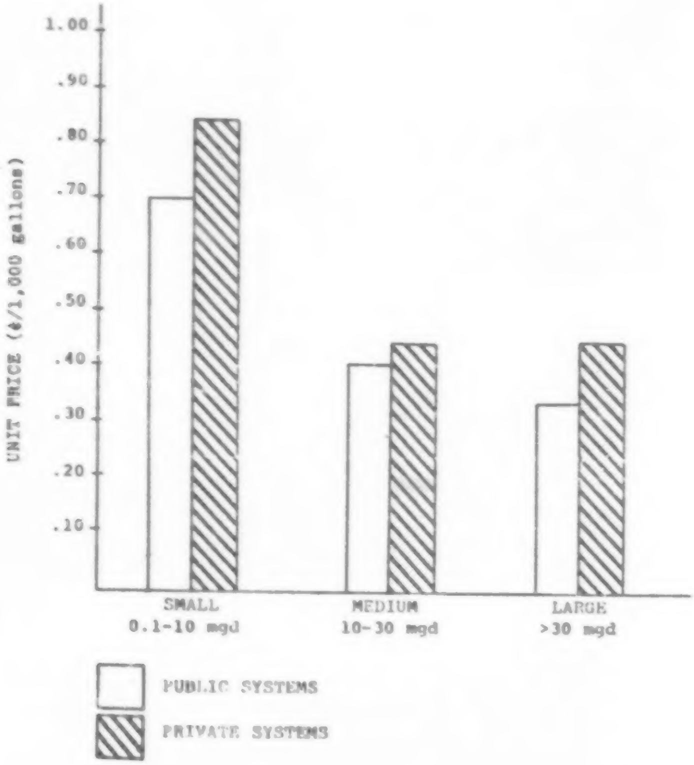

Figure 5-1. This figure shows the unit price of water in ¢/1,000 gallons.

Prices to the consumer are determined by rate structures, which in turn are a function of the institutional status of the consumer, i.e., industrial, commercial, or residential user, and are also a function of the cost of producing water. There are basically four types of rate structures:

1. Normal block structure
2. Inverted block structure
3. Flat rate structure
4. Non-incremental rate structure

Normal block structure applies particularly to industrial consumers and it gives a lower unit cost to the large volume users.

The inverted rate structure assigns higher unit costs to the largest consumers. The rationale behind this structure is that it encourages conservation through the economic incentive of higher prices for larger users.

The flat rate structure utilizes a single charge per unit for both large and small consumers. Only a small portion of all water supply utilities are currently using this rate structure.

Non-incremental rate structures are used to charge consumers when their water is not metered. The unit cost of water is dependent on the number and/or type of water consumption units (i.e., toilets, faucets, etc.) owned by the user under this rate structure.

No significant correlation appears to exist between either system size and rate structure, or type of ownership -- public vs. private -- and rate structure.

Prices charged for water are usually regulated by a state or local commission appointed to evaluate the need for rate hikes. Investor-owned utilities in all but two states are under the jurisdiction of state regulatory commissions. Public utilities either are regulated by local boards or else they are unregulated. Under such local control, water utilities formulate rate schedules to provide the gross revenues approved by the commissions.

Increased public understanding of water quality, as a result of the Safe Drinking Water Act, is expected to impress public regulatory agencies with the need for capital investments in the water supply industry. This, in turn, should lead the agencies to grant needed rate increases, thus aiding those plants requiring additional funds for compliance with the regulations.

5.2 Characteristics of Demand for Water

5.2.1 Trends in Demand

Public water supply systems provide water service for residential, commercial, industrial and general municipal purposes. Some of the many factors influencing trends in water use are: the level of water and sewer services; changes in customer bills for those services; changes in modes of living; the growth and nature of commercial, industrial, and institutional services; seasonal variations in the local economy; changes in climate; the extent of existing service-area development and redevelopment; the ability to extend service to additional areas; and the availability of an adequate, good-quality water supply.[1]

Table 5-2 shows the Water Resources Council's projections of the municipal water requirements to the year 2020. These projections indicate that water requirements will double between 1965 and 1980.

5.2.2 Elasticity of Demand

Records indicate that water use per customer tends to decrease following significant increases in water rates. Howe and Linaweaver[2] estimated the price elasticity of demand for water at -0.23 for metered, public sewer areas. Gottlieb[3] found it to be -0.4 in large cities and -0.65 in smaller communities. In an article by the American Water

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[1] W.L. Patterson, "Water Use," JAWWA, 65: 287, 1973.

[2] Charles W. Howe and F.P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," Water Resources Research, 3: 1, First Quarter, 1967.

[3] M. Gottlieb, "Urban Domestic Demand for Water: A Kansas Case Study," Land Economics, May 1963.

TABLE 5-2

PROJECTIONS OF PUBLIC WATER SYSTEM REQUIREMENTS[a]
(Millions of gallons per day)

	CONSUMPTION			
	1965	1980	2000	2020
North Atlantic	905	1,210	1,750	2,550
South Atlantic Gulf	363	600	1,000	1,500
Great Lakes	502	702	953	1,304
Ohio	230	300	430	620
Tennessee	46	64	95	140
Upper Mississippi	162	258	403	580
Lower Mississippi	175	238	343	497
Souris-Red Rainy	11	16	26	35
Missouri	221	280	339	397
Arkansas-White-Red	241	496	832	1,205
Texas Gulf	400	740	1,200	1,750
Rio Grande	108	220	400	670
Upper Colorado	14	30	35	50
Lower Colorado	203	310	515	840
Great Basin	94	154	255	345
Columbia-North Pacific	182	219	350	537
California	1,320	4,620	7,350	11,300
Alaska	7	24	46	75
Hawaii	39	65	106	173
Puerto Rico	21	35	50	75
TOTAL	5,244	10,581	16,478	24,643

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[a] Water Resources Council, The Nation's Water Resources, (Washington, D.C., 1968), p. 4-1-3.

Works Association (AWWA)[1] the implied elasticities were -0.08, -0.20, -0.22, -0.28, -0.33 and -0.34. These elasticities mean that for a given percent price increase, water use will decrease by a much smaller percentage (Table 5-3). For example, if the elasticity is -0.23 and the price of water increases by 20 percent the use of water will decrease by only 4.6 percent.

The elasticity for water used for lawn sprinkling is much greater than the elasticity for water in general. Howe and Linaweaver[2] found the sprinkling elasticity to be -0.7 in the arid West and -1.6 in the humid East. This indicates that if the price of water increases, people reduce the amount of sprinkling. Gottlieb's high elasticity (-0.65) may be due to sprinkling demands. This elasticity was estimated for small towns, which tend to have more space devoted to lawns and gardens than do large cities. Thus the amount of area devoted to lawns and gardens in a utility district will affect consumer response to price increases.

Technology also plays a role in determining water consumption. The examples that resulted in the AWWA elasticities of -0.20 and -0.34 were instances in which the population was able to convert from water-cooled air conditioners to non-water-using air conditioners. Once a price increase causes people to change their habits and buy water-saving appliances, it is not anticipated that any additional price increase will cause further reduction of water use.

Table 5-4 indicates the manner in which revenue will change as a function of elasticity and price change. Total revenue increases everywhere with water price increases, except when price elasticity is -0.65 and price increases are 100 percent or greater. It can be concluded from these data that if a water company, located in an area where lawn sprinkling is prevalent, doubles its rate, it may actually end up with less revenue than it received before the rate increase.

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[1] American Water Works Association, Committee of Water Use, "Water Use Committee Report," JAWWA, May 1973.

[2] Howe and Linaweaver, "Impact of Price on Demand and Its Relation to Design and Structure."

TABLE 5-3

THE RELATIONSHIP BETWEEN PRICE CHANGE AND DEMAND AS A FUNCTION OF ELASTICITY

PRICE ELASTICITY OF DEMAND FOR WATER	PERCENT DECREASE IN DEMAND FOR WATER			
	DUE TO 5 PERCENT INCREASE IN PRICE	DUE TO 20 PERCENT INCREASE IN PRICE	DUE TO 50 PERCENT INCREASE IN PRICE	DUE TO 100 PERCENT INCREASE IN PRICE
-0.08	0.4	1.6	4.0	8.0
-0.20	1	4.0	10.0	20.0
-0.22	1.1	4.4	11.0	22.0
-0.23	1.15	4.6	11.5	23.0
-0.28	1.4	5.6	14.0	28.0
-0.33	1.65	6.3	16.5	33.0
-0.34	1.7	6.8	17.0	34.0
-0.40	2.0	8.0	20.0	40.0
-0.65	3.25	13.0	32.5	65.0

TABLE 5-4

THE RELATIONSHIP BETWEEN PRICE CHANGE AND REVENUE AS A FUNCTION OF ELASTICITY

PRICE ELASTICITY OF DEMAND FOR WATER	PERCENT INCREASE IN REVENUE			
	DUE TO 5 PERCENT INCREASE IN PRICE	DUE TO 20 PERCENT INCREASE IN PRICE	DUE TO 50 PERCENT INCREASE IN PRICE	DUE TO 100 PERCENT INCREASE IN PRICE
-0.08	4.6	18.1	44.0	84.0
-0.20	3.95	15.1	35.0	60.0
-0.22	3.8	14.7	33.5	56.0
-0.23	3.8	14.5	32.7	54.0
-0.28	3.5	13.3	29.0	44.0
-0.33	3.4	12.4	25.3	34.0
-0.34	3.2	11.8	24.5	32.0
-0.40	2.9	10.4	20.0	20.0
-0.65	1.6	4.4	1.3	-30.0

5.3 Distribution of Costs

5.3.1 General

This section explores the projected distribution of treatment and monitoring costs over the next 10 years. This cost distribution was calculated on the basis of size of system, treatment facilities, and type of ownership.

5.3.2 Annual Monitoring Costs

The Safe Drinking Water Act mandates that water monitoring should begin 18 months after publication of the regulations. The projected monitoring costs for the first two years after implementation would be approximately $21.5 million per annum, then rise to an annual expenditure of approximately $28 million after the second year (Table 5-5).

5.3.3 Annual Capital Costs

Those systems which will be constructing new or additional treatment facilities will require some $1.049 billion in capital expenditures. It is expected that the construction and its attendant investment requirements will be spread evenly over a 5-year period. In general, a design period of 1.5 years would be needed before construction could begin, and construction would take from 1 to 3 years. It is assumed that no treatment facility design will begin until after implementation of the Revised National Primary Drinking Water Regulations.[1] For this reason, it is anticipated that the 5-year period of investment requirements will begin in 1979. In all calculations in this chapter treatment costs are based on average daily production rates.[2] Cost ranges based on maximum daily demand are displayed in Chapter Six.

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[1] Section 1412(b) of the Act specifies that the Administrator must propose revised regulations within 100 days of the publication of the National Academy of Sciences report under Section 1412(e) of the Act.

[2] Complete tables of costs by plant size and by treatment type for publicly-owned and privately-owned systems are in Appendix G of this report.

TABLE 5-5

TOTAL MONITORING COSTS[a]

SYSTEM SIZE	NUMBER OF SYSTEMS	POPULATION SERVED (MILLION PEOPLE)	($ million) 1976	1977	1978	1979	1980	COST PER YEAR 1981-1985	AVE. COST PER YEAR PER SYSTEM (DOLLARS)[b]	AVE COST PER YEAR PER CAPITA (DOLLARS)[b]
25-99	7,008	0.4	1.2	1.3	1.0	1.0	1.0	1.0	143.70	2.40
100-499	15,113	3.8	2.9	3.0	2.4	2.3	2.3	2.3	151.25	0.61
500-999	5,392	3.8	1.1	1.1	0.9	0.9	0.9	0.9	160.65	0.23
1,000-2,499	5,182	7.8	1.7	1.8	1.4	1.4	1.4	1.4	262.71	0.17
2,500-4,999	2,605	8.9	1.5	1.5	1.2	1.2	1.2	1.2	456.75	0.13
5,000-9,999	1,858	12.6	1.7	1.7	1.6	1.6	1.6	1.6	879.49	0.13
10,000-99,999	2,599	61.4	7.8	7.8	7.7	7.7	7.7	7.7	2,885.25	0.12
100,000-999,999	236	57.3	3.0	3.0	3.0	3.0	3.0	3.0	12,676.04	0.05
1,000,000	7	21.5	0.3	0.3	0.3	0.3	0.3	0.3	41,149.29	0.01
TOTAL COMMUNITY[c]	40,000	177.5	21.4	21.5	19.5	19.4	19.4	19.4		
TOTAL NON-COMMUNITY	200,000		---	---	8.4	8.4	7.5	7.5		
TOTAL[c]	240,000		21.4	21.5	27.9	27.8	26.9	26.9		

[a] Totals are based on mean costs.

[b] Based on 1981 monitoring costs.

[c] Totals may not add due to rounding.

Assumptions used to partition special monitoring costs by years:

1. For surface systems special monitoring costs were divided evenly between Year 1 and Year 2.
2. For groundwater systems special monitoring costs were divided into 25 percent in Year 1, 50 percent in Year 2, and 25 percent in Year 3.
3. Nitrate, arsenic, barium, cadmium, chromium and fluoride are found only in groundwater.
4. Lead, mercury, and selenium are found in both surface and groundwater in a random manner.
5. Silver was not found in violation.
6. Non-community systems will spread their costs evenly over the first 2 years of enforcement.

The total annual capital costs, by size of system, are displayed in Table 5-6. Projections indicate that systems serving between 25 and 99 people will have an average per capita capital expenditure of about $163 to treat their water, while the average per capita cost for systems serving more than one million people will be only $8.78. The private (investor-owned) segment of the water supply industry will pay 17.7 percent of the total treatment costs, while the public sector will pay 82.3 percent. Yet, this does not necessarily mean that the burden will fall most heavily on the public sector because systems serving under 100 people -- those with relatively high costs of capital and relatively poor operating records -- are concentrated in the private sector.

5.3.4 Annual Operation and Maintenance Costs

It is assumed that O&M costs will begin concurrently with capital costs and will aggregate yearly until an equilibrium is reached at the end of the fifth year. Table 5-7 displays the total O&M expenditures, by size of system, for the 5-year period ending in 1983.[1]

The investor-owned companies would pay an annual O&M cost of almost $33 million after 5 years, while the public utilities would pay $225.8 million in 1983. However, private rather than public companies must bear a higher proportion of O&M costs for the small water companies. When all costs are included, the private sector's portion of the bill for systems serving 100 or fewer persons is over three times that of the public sector.

Systems serving between 25 and 99 people will pay an average per capita cost of approximately $12.40 per year for O&M expenses, while systems serving between 100,000 and 1,000,000 people will pay an average of $6.46 per capita.

5.3.5 Total Annual Costs

The total annual costs are considered to be the sum of the O&M costs, monitoring costs, and ownership costs. The ownership costs are based on an annual 11 percent debt

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[1] Complete tables of costs by plant size and by treatment type for publicly-owned and privately-owned systems are in Appendix G of this report.

TABLE 5-6

TOTAL ANNUAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	($ million)						TOTAL PER PLANT (DOLLARS)	TOTAL PER CAPITA (DOLLARS)
			1979	1980	1981	1982	1983	TOTAL[a]		
25-99	2,746	166,894	5.77	5.77	5.24	5.24	5.24	27.3	9,929	163.36
100-499	5,039	1,309,035	19.83	19.83	18.39	18.39	18.39	94.8	18,819	72.44
500-999	1,562	1,126,992	10.28	10.28	9.73	9.73	9.73	49.8	31,855	44.15
1,000-2,499	1,450	2,230,287	13.89	13.89	13.28	13.28	13.28	67.6	46,650	30.33
2,500-4,999	690	2,382,206	21.01	21.01	20.22	20.22	20.22	102.7	148,835	43.11
5,000-9,999	427	2,914,450	23.44	23.44	22.64	22.64	22.64	114.8	268,848	39.39
10,000-99,999	582	13,984,736	76.29	76.29	73.74	73.74	73.74	373.8	642,268	26.73
100,000-999,999	52	11,776,428	35.60	35.60	34.34	34.34	34.34	174.2	3,350,385	14.79
>1,000,000	2	5,010,781	8.80	8.80	8.80	8.80	8.80	44.0	22,000,000	8.78
TOTAL COMMUNITY CAPITAL COSTS[a]	12,550	40,901,812	214.92	214.92	206.39	206.39	206.39	1049.0		

[a] Totals may not add due to rounding.

TABLE 5-7

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	($ million) 1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,746	166,654	.45	.69	1.29	1.68	2.07	754	12.41
100-499	5,039	1,309,036	1.56	3.12	4.46	5.79	7.12	1,413	5.44
500-999	1,562	1,126,992	.84	1.67	2.37	3.08	3.78	2,418	3.35
1,000-2,499	1,450	2,230,287	1.13	2.26	3.18	4.10	5.03	3,466	2.25
2,500-4,999	690	2,382,206	3.19	6.37	9.33	12.30	15.26	22,119	6.41
5,000-9,999	427	2,914,450	3.66	7.33	10.69	14.04	17.40	40,752	5.97
10,000-99,999	582	13,964,736	15.63	31.27	45.54	59.61	74.09	127,295	5.30
100,000-999,999	52	11,776,428	15.66	31.72	46.50	61.26	76.06	1,462,654	6.46
>1,000,000	2	5,010,781	11.60	23.20	34.80	46.40	58.00	29,000,000	11.58
TOTAL COMMUNITY O&M COSTS[a]	12,550	40,901,812	53.92	107.63	158.15	208.46	258.80		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

service (principal plus interest), and an added factor of 3 percent of capital costs to cover land amortization, insurance, taxes and other ownership costs. The total annual costs based on average daily production and size of system are shown in Table 5-8. The weighted average per capita cost of treatment for systems serving between 25 and 99 people is $35.28, while the weighted average per capita cost of treatment for systems serving between 100,000 and 1,000,000 people is $8.53. Systems serving over one million people pay $12.80 per capita per year because of the high percentage of plants needing clarification.

TABLE 5-8

TOTAL ANNUALIZED TOTAL EXPENDITURES[a] BY SIZE OF SYSTEM

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	($ million)					TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
			1979	1980	1981	1982	1983		
25-99	2,746	166,894	1.26	2.52	3.64	4.76	5.89	2,144	35.28
100-499	5,039	1,309.038	4.34	8.67	12.59	16.51	20.39	4,046	15.58
500-999	1,562	1,126,992	2.28	4.56	6.61	8.67	10.75	6,876	9.53
1,000-2,499	1,450	2,230,287	3.07	6.15	8.93	11.71	14.49	9,997	6.50
2,500-4,999	690	2,382,206	6.13	12.26	18.02	23.82	29.64	42,956	12.44
5,000-9,999	427	2,914,450	6.95	13.88	20.42	26.95	33.47	78,391	11.49
10,000-99,999	582	13,984,736	26.31	52.62	77.22	101.82	126.42	217,213	9.04
100,000-999,999	52	11,776,428	20.84	41.69	61.27	80.86	100.45	1,931,708	8.53
>1,000,000	2	5,010,781	12.83	25.66	38.50	51.33	64.16	32,080,000	12.80
SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c]	12,550	40,901,812	84.00	168.01	247.20	326.43	405.66		
MONITORING			19.40	19.40	19.40	19.40	19.40		
SUBTOTAL COMMUNITY[c]			103.40	187.41	266.60	345.83	425.06		
SUBTOTAL NON-COMMUNITY[c]			10.00	10.00	10.70	11.50	12.30		
TOTAL[c]			113.40	197.41	277.30	357.33	437.36		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

CHAPTER SIX

ECONOMIC IMPACT ANALYSIS

6.0 Introduction

The aggregate costs of implementing the Interim Primary Drinking Water Regulations were developed in previous chapters This chapter examines the impact of the regulations on the individual consumer by exploring the impact on residential, commercial, and industrial water users.

6.1 Per Capita Monitoring Cost Impacts

Upon implementation of the Interim Primary Drinking Water Regulations, all communities will have to bear the costs of monitoring their drinking water. The total cost per capita to perform this monitoring is demonstrated in Table 6-1. In order to develop these costs, the number of samples required per person, as a function of the size of a given system, had to be determined. This is not difficult for chemical monitoring, since under ordinary circumstances the required sampling frequency per system depends only on the system type (groundwater vs. surface-water; community vs. other) and not on the number of people served. Thus, for example, a 25-person groundwater system must perform 0.02 (0.5 analyses ÷ 25 people) chemical analyses per person per year in the first 2 years after implementation of the regulations, and 0.013 (0.33 analyses ÷ 25 people) chemical analyses per person per year thereafter. A surface-water system serving one million people must perform 10^{-6} (1 analysis ÷ 1,000,000 people) chemical analyses per person per year. A similar cost analysis was performed to determine the monitoring costs due to coliform sampling.

6.2 Treatment Cost Impacts

The additional treatment necessitated by the Interim Primary Drinking Water Regulations will result in additional costs to water supply systems, costs which in turn will be passed on to water customers in the form of higher rates.

TABLE 6-1

ANNUAL MONITORING COSTS PER PERSON SERVED VERSUS SYSTEM SIZE AND TYPE FOR COMMUNITY WATER SYSTEMS

SYSTEM SIZE	SYSTEM TYPE SURFACE ($)	 GROUND ($)
25	7.20 - 15.05	3.35 - 7.05
100	1.80 - 3.75	0.85 - 1.75
500	0.35 - 0.75	0.15 - 0.35
1,000	0.20 - 0.40	0.10 - 0.20
2,500	0.15 - 0.30	0.05 - 0.15
5,000	0.10 - 0.25	0.05 - 0.15
10,000	0.10 - 0.20	0.05 - 0.15
100,000	0.05 - 0.15	0.05 - 0.15
1,000,000	a - 0.05	a - 0.05
10,000,000	a - a	a - a

[a] Less than $0.05.

These costs and their impact will vary with both the size of the water system and the degree of treatment required. Table 6-2 illustrates in a very general sense the differences in average costs for four size categories. These are weighted average costs per capita per year. They are not indicative of the extremes in costs within each size category which would be expected for very small systems requiring extensive treatment and for very large systems requiring minimal treatment. These cost extremes are shown for each treatment type and for the four size categories in Table 6-3. In this table the higher per capita costs shown for the small, medium, and large system categories represent the costs which would be incurred if the smallest plant in the category built treatment capacity to treat the present maximum daily demand; the lower per capita costs represent the costs which would be incurred if the largest plant in the category built a treatment facility for the present average daily production. For the smallest systems, the per capita costs are based solely on average daily production, since it was assumed that the increased costs required to enlarge the plants to treat for maximum daily demand would impose too great a financial burden on the individual consumers in these systems.

TABLE 6-2

DISTRIBUTION OF COSTS FOR THOSE SYSTEMS NEEDING TREATMENT BY SYSTEM CATEGORY

	SMALLEST SYSTEMS (25-99 PEOPLE SERVED)	SMALL SYSTEMS (100-9,999 PEOPLE SERVED)	MEDIUM SYSTEMS (10,000-99,999 PEOPLE SERVED)	LARGE SYSTEMS (Over 100,000 PEOPLE SERVED)
Annual Capital Costs ($ million)	3.8 - 6.4	60.2 - 101.4	52.3 - 88.1	30.5 - 51.2
Annual O&M Costs ($ million)	2.1	48.6	74.1	134.1
Annual Monitoring Costs ($ million)	0.3 - 0.6	0.6 - 1.3	1.2 - 2.5	1.3 - 2.9
TOTAL ANNUAL COSTS ($ million)	6.2 - 9.1	109.4 - 151.3	127.6 -164.7	165.9 -188.2
Weighted Average Costs per Capita per Year ($)	37 - 54	11 - 15	9 - 12	10 - 11
Increase in Household Monthly Water Bill ($)[a]	9.60-14.05	2.85- 3.95	2.35- 3.95	2.55- 2.90

[a] Assumes 3.11 persons per household and that all increases in costs are passed on to the consumer.

TABLE 6-3

ANNUAL PER CAPITA AND MONITORING COST RANGES FOR FOUR SIZE CATEGORIES

	SMALLEST SYSTEMS (25-99 PEOPLE SERVED)	SMALL SYSTEMS (100-9,999 PEOPLE SERVED)	MEDIUM SYSTEMS (10,000-99,999 PEOPLE SERVED)	LARGE SYSTEMS (OVER 100,000 PEOPLE SERVED)
TREATMENT[a]				
Disinfection	3.85 - 2.10	2.75 - 0.30	0.45 - 0.15	≤ 0.25
Turbidity Control	152.00 - 52.00	78.00 - 16.00	20.00 - 12.50	≤15.00
Heavy Metal Removal	237.00 - 101.00	142.00 - 25.50	35.00 - 13.00	≤18.00
Lead Control	2.60 - 1.20	1.80 - 0.30	0.40 - 0.20	≤ 0.30
Fluoride/Arsenic Removal	11.80 - 7.85	11.30 - 3.15	5.00 - 3.15	≤ 3.55
MONITORING	15.80 - 0.85	3.75 - 0.05	0.20 - 0.05	≤ 0.05

[a] Lower cost limit based on assumption that treatment plant built to treat average daily demand and upper cost limit based on maximum daily demand, except for the Smallest Systems category where costs are based on average daily demand only.

While the combination of treatments required depends on the composition of the impurities in the water, a probability analysis showed that no more than two types of treatment would be used within a single system. The most commonly required treatment combinations are listed in Table 6-4, along with their frequencies of need by system size.

If the present distribution of costs continues, the additional costs of chlorination and clarification -- the most frequent treatment processes -- will result in the pattern displayed in Table 6-5. Should rates align with usage, then all users in a particular system would pay the same rate (e.g., 15.5 cents per 1,000 gallons would be the price increase for residential, commercial, industrial, and other users in the 100-person "chlorination only" system).

Assuming that the current average price for water is $0.60 per 1,000 gallons, the smallest household increase indicated in Table 6-5 would represent a 7 percent price hike and the largest would represent a 336 percent price hike. Correspondingly, a base price of $0.30 per 1,000 gallons would mean a rate increase of 14.1 percent at the low end of the scale and 672 percent at the high end. Due to the wide range of base rates across different systems, it is impossible to develop a realistic "average" rate.

Historically, industrial and commercial water usage has been inelastic to price increases.[1] For residential (household) customers, water appears to be price elastic with respect primarily to lawn sprinkling. Yet, this does not necessarily mean that higher treatment costs can be readily passed to customers in the form of higher rates. If price elasticity in households is -0.65, as Gottlieb believes,[2] and prices increase 100 percent, as they well may in small systems requiring expensive treatments, then water suppliers' total revenue will fall. Total revenue, rather than rates *per se*, is the critical figure for water suppliers. As demand falls in the first round of rate hikes, a second stage increase may be necessary to cover the largely fixed costs of water treatment.

Financial implications aside, the political repercussions of increasing water rates dramatically could be

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[1] Patterson et al., "Water Use," *JAWWA*, 1973.

[2] M. Gottlieb, "Urban Domestic Demand for Water: A Kansas Study," *Land Economics*, May 1963.

TABLE 6-4

PROBABILITY OF NEEDING TREATMENT COMBINATIONS BY SYSTEM SIZE
(% of Systems)

PROCESS	SYSTEM SIZE (POPULATION SERVED)							
	25 - 99		100 - 9,999		10,000 - 99,999		Over 100,000	
	SURFACE	GROUND	SURFACE	GROUND	SURFACE	GROUND	SURFACE	GROUND
No Treatment	1	67	18	74	28	79	71	81
Chlorination Only	3	19	4	12	4	6	5	4
Clarification Only	72		65		59		20	
Ion Exchange Only		5		6	1	6	2	7
pH Control Only		1		2		2		2
Activated Alumina Only		4		4		5		5
Chlorination & Ion Exchange	2	2		1	2	1		
Chlorination & Activated Alumina		1		1				
Chlorination & Clarification	21		9		5		1	
Clarification & Ion Exchange			2				1	

TABLE 6-5

PRICE IMPACTS OF CHLORINATION AND CLARIFICATION TREATMENTS BASED ON PRESENT AVERAGE DISTRIBUTION OF TOTAL COSTS

		SYSTEMS SIZE POPULATION SERVED		
	CHLORINATION ONLY	100[a]	5,000[b]	100,000[c]
1.	Increase in Unit Cost (cents/1,000 gal)	15.48	3.48	3.06
2.	Total Annual Systems Increase (dollars)[d]	616	9,780	194,300
3.	Increase in Household Unit Cost (cents/1,000 gal)[e]	21.46	4.82	4.24
4.	Increase in Commercial Unit Cost (cents/1,000 gal)[f]	10.89	2.45	2.15
5.	Increase in Industrial Unit Cost (cents/1,000 gal)[g]	6.52	1.47	1.29
6.	Increase in Other Unit Cost (cents/1,000 gal)[h]	17.03	3.83	3.37

		SYSTEMS SIZE POPULATION SERVED		
	CLARIFICATION ONLY	100[a]	5,000[b]	100,000[c]
1.	Increase in Unit Cost (cents/1,000 gal)	142.04	30.33	20.04
2.	Total Annual Systems Increase (dollars)[d]	5,651	85,238	1,272,510
3.	Increase in Household Unit Cost (cents/1,000 gal)[b]	196.92	42.05	27.78
4.	Increase in Commercial Unit Cost (cents/1,000 gal)[c]	99.95	21.34	14.10
5.	Increase in Industrial Unit Cost (cents/1,000 gal)[d]	59.81	12.77	8.44
6.	Increase in Other Unit Cost (cents/1,000 gal)[e]	156.24	33.36	22.04

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[a] Based on 109 gallons (0.412 m^3) per capita day production.

[b] Based on 154 gallons (0.582 m^3) per capita day production.

[c] Based on 174 gallons (0.658 m^3) per capita day production.

[d] Costs include annualized capital costs plus O&M plus monitoring.

[e] Assumes residential customers pay 61 percent of total costs and use 44 percent of output.

[f] Assumes commercial customers pay 19 percent of total costs and use 27 percent of output.

[g] Assumes industrial customers pay 8 percent of total costs and use 19 percent of output.

[h] Assumes other sales pay 11 percent of total costs and use 10 percent of output.

substantial. Unless local customers clearly understand the reasons behind the interim primary regulations and the related rate hikes, they may reject both. However, the mandatory notification requirement contained in the regulations should serve to inform the local residents of contaminant problems with their water.

In examining the per capita costs in Tables 6-2 and 6-3, it is apparent that considerable attention should be given to the small (under 2,500 population served) water systems. Table 6-6 lists the capital and O&M costs associated with each treatment technology for the systems serving fewer than 2,500 people, while Table 6-7 lists the per capita cost and cost per 1,000 gallons for these same systems. When one looks at the capital costs for clarification and ion exchange for these small systems, it is apparent that the per capita burden of treatment is too great for any small community to bear. It is equally true, however, that these small systems will need to comply with the Interim Primary Drinking Water Regulations.

The small systems (as well as larger systems) would probably consider the following options rather than install expensive treatment processes:

1. Shift source of water from surface to ground;
2. Change groundwater sources;
3. Consolidate (merge systems);
4. Purchase finished water;
5. Disband the community system and go to individual well sources.

It is possible to develop cost data for options 1 and 2. In both of these options it is necessary to develop well costs, which are dependent on the initial cost of structures and equipment, the useful life of structures and equipment, and the cost of operation and maintenance. As in any engineering project, it is possible to vary the proportion of all three cost factors. A complete description of well costs can be found in Rural Water Systems Planning and Engineering Guide by Campbell and Lehr.[1] For purposes of

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[1] Michael D. Campbell and Jay H. Lehr, Rural Water Systems Planning and Engineering Guide, Commission on Rural Water (Washington, D.C., 1973).

TABLE 6-6

CAPITAL AND O&M TREATMENT COSTS FOR SMALL WATER SYSTEMS[a] USING AVERAGE DAILY CURRENT PRODUCTION RATES

POPULATION SERVED GROUP	CHLORINATION (DISINFECTION)		DIRECT FILTRATION (CLARIFICATION)		ION EXCHANGE (HEAVY METAL REMOVAL)		pH (LEAD CONTROL)		ACTIVATED ALUMINA (FLUORIDE/ARSENIC REMOVAL)	
	CAPITAL ($)	O&M	CAPITAL ($)	O&M	CAPITAL ($)	O&M	CAPITAL ($)	O&M	CAPITAL ($)	O&M
25-99	690	70	21,000	1,900	41,000	2,900	690	3	2,600	220
100-499	1,200	190	30,000	2,200	68,000	4,800	1,200	12	6,100	630
500-999	1,800	440	41,000	2,500	100,000	7,200	1,800	38	12,000	1,500
1,000-2,499	2,500	850	52,000	2,700	140,000	9,900	2,500	90	22,000	3,000

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[a] Based on average sized systems in the EPA Inventory of Community Water Supplies.

TABLE 6-7

ANNUAL PER CAPITA TREATMENT COSTS[a] AND TREATMENT COSTS[a] PER 1,000 GALLONS FOR SMALL SYSTEMS

POPULATION SERVED GROUP	CHLORINATION (DISINFECTION)		DIRECT FILTRATION (CLARIFICATION)		ION EXCHANGE (HEAVY METAL REMOVAL)		pH (LEAD CONTROL)		ACTIVATED ALUMINA (FLUORIDE/ARSENIC REMOVAL)	
	ANNUAL PER CAPITA ($)	¢/1,000 GAL	ANNUAL PER CAPITA ($)	¢/1,000 GAL	ANNUAL PER CAPITA ($)	¢/1,000 GAL	ANNUAL PER CAPITA ($)	¢/1,000 GAL	ANNUAL PER CAPITA ($)	¢/1,000 GAL
25-99	2.70	7	90	250	145	400	1.70	5	9.75	27
100-499	1.30	3	24	60	60	150	0.75	2	6.00	15
500-999	0.90	2	12	28	30	69	0.40	1	4.50	10
1,000-2,499	0.75	2	6	12	20	42	0.30	0.5	4.00	8

[a] Costs based on annual ownership cost and annual O&M costs for average sized system in each group.

illustration, the cost will be developed for a 6-inch diameter 80-foot deep medium high capacity sand well using a 40-gallon per minute submersible turbine pump with 400 feet total lead. The well cost of $6,177 includes setting up and removing the drilling equipment, drilling the well (test drilling not included), all casings and liners, including construction casings, grouting and sealing the annular spaces between casings, and between casings and the boreholes, well screens and fittings, gravel pack materials, and placing and conducting one 8-hour pumping test. Not included in this estimate are preliminary hydraulic tests and site exploration. The submersible pump would cost $3,921. It is anticipated that the pump will remain maintenance-free for a period of 5 years before major repairs would be needed. A third cost associated with the construction of a new water system is the water transmission cost. For example, it would cost $35,000 per mile to lay a 6-inch diameter pipe. Finally, any treatment costs associated with the new water source must be considered. Briefly summarizing the results of this example, it would cost $10,098 to construct the well and install a pump, with a cost of $35,000 per mile for transmission lines.

If systems choose options 3 or 4 above, then the primary cost to consider is the cost of the transmission lines to furnish water to all parts of the system from the new source.

Figure 6-1 shows the equivalent monthly cost of operating a single domestic well. A typical well would cost $1,200 to drill and the average low capacity pumping system would cost $980.[1] It would cost about $22 per month to run a single-family well. Presumably, if municipal water costs exceeded this cost and groundwater sources were available, people would choose to develop their own water source rather than purchase water from a community system.

Table 6-8 shows the total national costs of applying the recommended treatment technologies to comply with the Interim Primary Drinking Water Regulations. It is apparent that many of these costs will not be spent on treating these small systems. What is not known, however, is the number of systems which will purchase water from existing systems, thereby increasing treatment costs for those systems. Until these two factors can be determined, it appears reasonable to assign the costs to small systems even though they may not ultimately treat their present source of water.

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[1] Campbell and Lehr, Rural Water Systems Planning and Engineering Guide, 1973.

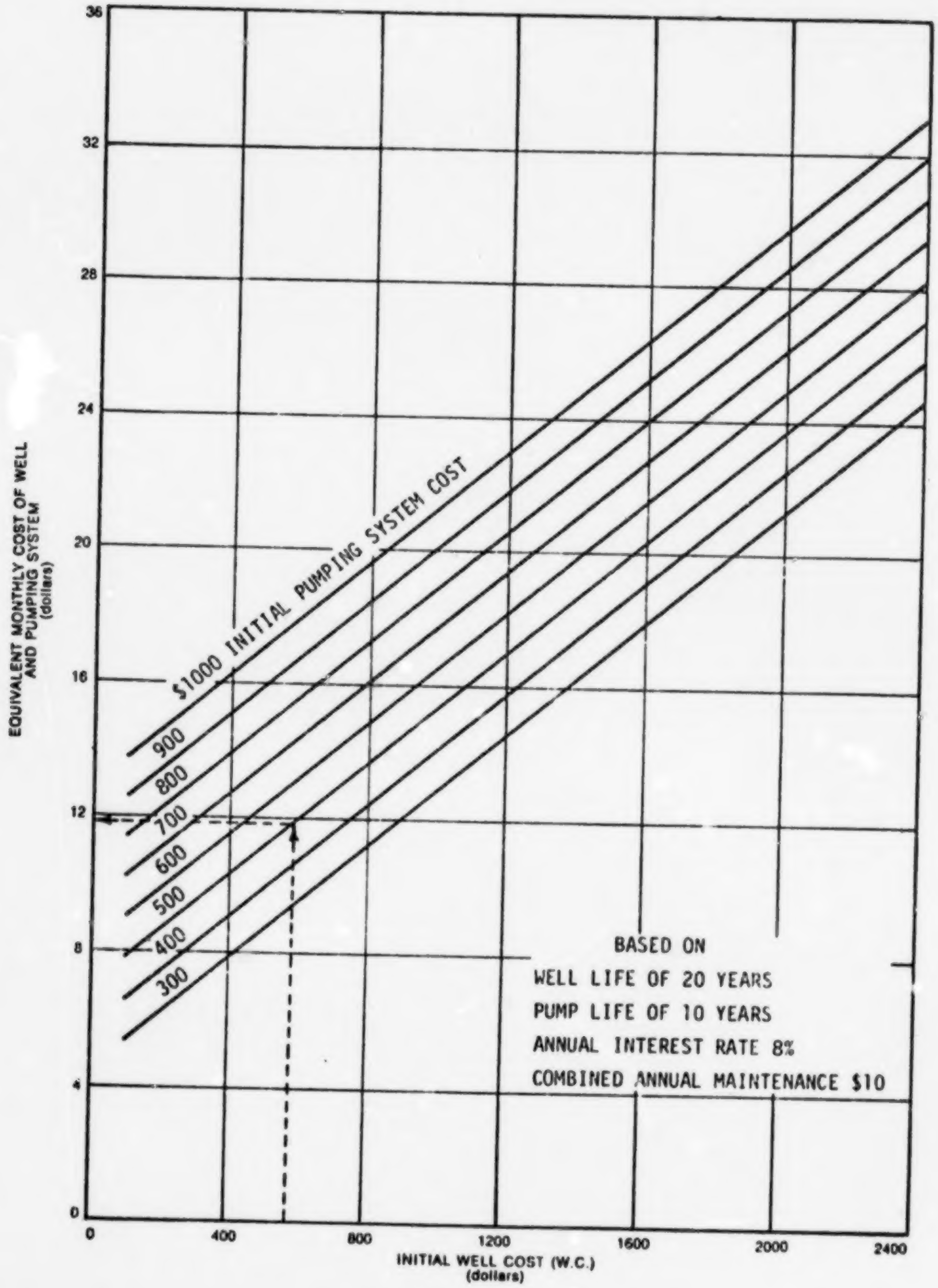

Figure 6-1. This figure displays the monthly cost of wells and pumping systems. (Michael D. Campbell and Jay H. Lehr, Rural Water Systems Planning and Engineering Guide, p. 119.)

TABLE 6-8

BREAKDOWN OF NATIONAL COSTS OF TREATING CONTAMINANTS IN DRINKING WATER BY TREATMENT TYPE AND POPULATION SERVED GROUPS[a]

(Capital Costs in $1,000)

POPULATION SERVED GROUP	DISINFECTION	CLARIFICATION	ION EXCHANGE	pH CONTROL	ACTIVATED ALUMINA
25-99	1,052	5,292	19,926	94	900
100-499	2,892	19,590	67,728	332	4,288
500-999	1,092	12,013	33,700	167	2,784
1,000-2,499	1,220	19,656	42,140	205	4,422
2,500-4,999	1,582	32,250	65,330	277	3,256
5,000-9,999	1,596	29,970	79,380	312	3,540
10,000-99,999	5,100	124,800	234,000	930	8,970
100,000-999,999	2,520	91,800	77,000	420	2,480
≥1,000,000	0	44,000	0	0	0
TOTAL	17,054	379,371	619,204	2,737	30,640

[a] Assuming treatment of average daily production.

6.3 Macroeconomic Effects

The macroeconomic effects of the Interim Primary Drinking Water Regulations are expected to be minimal. On the average, the regulations will cause an increase in water rates of 9.5 percent spread over several years. If this increase occurred in one year, the resulting increase in the Consumer Price Index (CPI) would be less than 0.001 percent. Since the costs of these regulations will be incurred over several years, the average annual increase in the CPI will be even less. The Chase Econometric Model was used to examine the impact of all existing pollution abatement regulations.[1] The analysis showed that there will be an average increase in the CPI for 1974 to 1980 of less than 0.1 percent due to these pollution abatement regulations.

6.4 Energy Use

It is estimated that approximately 21,200 billion Btu's per year will be required to operate plants and produce chemicals for the various treatment systems necessary for the 40,000 community systems to meet the regulations. This is 0.028 percent of the 1973 national energy consumption, based on the 1974 Statistical Abstract. The increase in energy use will depend on a number of factors, including whether pollution in surface sources of water is successfully controlled. There will be no direct energy savings from the recommended action.

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[1] Chase Econometric Associates, Inc., "The Macroeconomic Impacts of Federal Pollution Control Programs," prepared for the Council of Environmental Quality and the Environmental Protection Agency, January 1975.

CHAPTER SEVEN

CONSTRAINTS TO IMPLEMENTATION OF THE INTERIM PRIMARY DRINKING WATER REGULATIONS

7.0 Introduction

This chapter explores the non-economic constraints which may hinder implementation of the Interim Primary Drinking Water Regulations. The economic factors were examined in the preceding three chapters. An examination of these non-economic constraints on the implementation of the interim regulations reveals that potential problem areas include the availability of some chemicals and the availability of trained manpower.

Chemical shortages might occur for some coagulants, mainly alum, ferric chloride, synthetic polymers, and hypochlorites. It is anticipated, however, that these shortages would be only short-term local problems. Even these local difficulties can be eliminated if the water supply industry maintains contact with chemical suppliers, so that the supply of these key chemicals will keep pace with growing demand.

It is anticipated that a shortage of state certified laboratory facilities could delay full implementation of the water quality monitoring program called for under the Interim Primary Drinking Water Regulations. However, there are a sufficient number of uncertified laboratories available to perform all the routine analyses necessitated by the regulations.

7.1 Chemical Constraints

The timely implementation of the Interim Primary Drinking Water Regulations depends greatly on the availability of key chemicals and supplies needed in the treatment of drinking water. The demand for some chemicals will require a production increase of several percent above present levels. The demand for many of these chemicals may be further exacerbated by the concurrent demands of other Federally mandated air and water pollution control programs.

The chemical constraint analysis was based on the following assumptions:

1. Chlorination units will be installed in 27.5 percent of those water systems which do not presently chlorinate;
2. All surface water systems which do not presently clarify will do so;
3. The numbers and types of systems which exceeded one or more maximum contaminant levels in the 1969 CWSS study are representative of the country's 40,000 community systems;
4. No major treatment activity will begin until March 1977, and the maximum chemical demands will not be felt until two years later.

A critical evaluation has been made for those chemicals which would require an increase in production of 5 percent or more due to implementation of the Interim Primary Drinking Water Regulations. The current and anticipated supply and demand factors for alum, ferric chloride, synthetic polymers, and hypochlorites were specifically examined. Table 7-1 gives a summary of the findings of the chemical constraints analysis.

Table 7-2 summarizes the number of systems which are expected to need treatment to reduce the concentration of certain contaminants to a level below the maximum permitted under the Interim Primary Drinking Water Regulations.

7.1.1 Coagulation

One of the most important processes conventionally utilized in the treatment of drinking water is coagulation and subsequent sedimentation or filtration. Strictly speaking, engineers use the term "flocculation" to refer to the chemical agglomeration of suspended solids and colloidal materials, and the term "settling" to refer to the gravitational descent of these particles to the floor of the sedimentation basin.

TABLE 7-1

CONSTRAINT ANALYSIS OF KEY WATER TREATMENT CHEMICALS AND SUPPLIES[a]

Chemical or Supply	Process	Unit Cost	Current U.S. Prod./Yr.	(1980) Added Demand from IPDWS/Yr.[c]	% Current Product'n	Added cost/yr (millions of 1974 dollars)	Availability Outlook[d]
Alum	Coagulation	$85/ ton	1,136,000 tons (1973)	≤ 185,000 tons	16.3%	max.$16.2	Generally favorable, except that essentially all alum production is dependent on foreign imports of bauxite. Politically sensitive.
Ferric Chloride	Coagulation	$100/ ton	115,000 tons	≤25,000 tons	≤22%	$ 2.5	The U.S. is self-sufficient in chloride production, but must import 50% of its iron. Both are available in more than adequate quantities. Cost is high.
Synthetic Polymers[b]	Coagulation Coagulant Aids-Filter Aids	$1.00/ lb.		≤ 5,000 tons		max.$10.0	While there are a number of component monomers in short supply, this is not expected to create any significant supply problems.
Lime	Coagulant Aid - pH Control - Calcium Hypochlorite production	$25/ ton	250,000,000 tons	250,000 tons	1.0%	$6.25	Extremely abundant in U.S. Improvements in extraction and transport techniques of limestone will be necessary to keep costs of lime low.
Sand	Filtration (pressure and multi-media)	$1.30/ ton	913,375,000 tons	111,000 tons	0.01%	$0.15 (assumes yearly replacement)	U.S. Resources are extremely abundant on the whole, although local depletions are occurring near heavily urbanized metropolitan areas.
Anthracite	Filtration (Rapid Sand Multi-media)	$12/ ton	7,100,000 tons	116,700 tons	1.65%	$1.40 (assumes yearly replacement)	While production costs may continue to rise, there will be no trouble meeting additional demands. All anthracite is found in the northeastern sector of Pennsylvania.
Chlorine	Disinfection	10¢/ lb.	12,000,000 tons	83,000 tons	0.69%	$16.6	Supply should be adequate. Sensitive to power industry and fluctuations in electric generation. Supply was inadequate in 1972 due to economic conditi
Hypochlorites	Disinfection	$41/ 100 lb	150,000 tons	10,000 tons	6.7%	$8.2	Production presently at capacity demand for pools strong. Price hikes forthcoming.
Ion Exchange Resins	Inorganic Cation Removal	$60/ ft^3	styrene resins and copolymers	215,300 ft^3 initially	1.4%	≤$13.0 initially[a]	No problems should occur if the petroleum industry remains stabl - General inflationary trends will be reflected in costs of resins.
	Nitrate Removal		351,500 tons	68,550 ft^3 initially	0.45%	≤$4.0 initially[a]	
Sulfuric Acid	Ion exchange-Regeneration	$53/ ton	31,590,000 tons	235,000 tons	0.75%	$12.5	Abundant. Periodic competition for sulfur from fertilizer industry may affect seasonal costs.
Sodium Hydroxide	Ion Exchange - Regeneration	$12/ 100 lb	10,680,000 tons	75,400 tons	0.71%	$18.1	Tied to chlorine manufacture. Inventories are presently low. Prices will rise by late 1975.
Membranes R/O	Organic Removal	25-40¢/ 1000gal. treated		Cellulose acetate not competitive.			Economically undesirable, althou may be used in special cases of high organic concentrations. Cellulose acetate can easily be produced to meet small demands.
Soda Ash	pH control Heavy metal removal	$50/ ton	sodium carbonate 7,496,000 tons	46,000 tons	0.61%	$2.2	Abundant.
Activated Alumina	Defluoridation	$14/ 100 lb.	bauxite 1,812,000 tons	9,590 ft^3	0.28% of bauxite production	$1.7	See Alum.

[a] List prices as of April 18, 1975 for large lots f.o.b. New York.

[b] See text for further explanation

[c] IPDWS = Interim Primary Drinking Water Standards.

[d] Reflects chemical supply industry impressions based on current usage trends in the water supply industry. If there are any large scale technology shifts this outlook would change.

TABLE 7-2

NUMBER[a] OF COMMUNITY SYSTEMS WHICH WILL NEED TREATMENT TO MEET INTERIM PRIMARY DRINKING WATER REGULATIONS

TREATMENT	PRIMARY CONTAMINANT(S) TREATED	NUMBER OF SYSTEMS
Chlorination	Coliform	5,557
Clarification - Direct Filtration	Turbidity	2,126
Ion Exchange	Ba, NO_3, Cd, Cr, Se, Ra, Hg	2,481[b]
Activated Alumina	Fluoride, As	1,702
pH Control	Pb	648

[a] Based on number of systems violating one or more maximum contaminant levels in the 1969 CWSS study.

[b] Includes 769 systems estimated to violate mercury standard.

Coagulation is responsible for decreasing turbidity in water supplies. The regulations state that the maximum contaminant level of turbidity in drinking water is not to exceed one turbidity unit; many reservoirs, however, have recorded levels in the tens of turbidity units. Coagulation can remove to some degree all of the other contaminants to which the regulations are addressed; i.e., inorganics and microbiological pollutants.

Alum is presently the flocculant most widely used in the water treatment industry. It is a low-cost material and its effectiveness can be enhanced by the addition of polyelectrolytes. Alum production in 1973 was 2.27 billion pounds (1,136 million tons), approximately 28 percent (640 million pounds) of which was used in the treatment of supply water. Projections indicate that a maximum additional 370 million pounds would be necessary to meet the new standards, depending on the ability of the newly developed electrolyte coagulants to replace alum. Opinions solicited from the manufacturing industry indicate that the future supply of alum to meet this demand should be plentiful. Alum accounts for $20.5 million of current water treatment costs, and may cost as much as an additional $16.2 million by 1980.

Ferric salts, and particularly ferric chloride, are a second group of coagulants which are used in water treatment. In the past, the use of ferric chloride in water treatment has been restricted because it is corrosive to most common metals, including those used in pipes. It is expected that the advent of new pipe and storage tank materials, particularly PVC, fiber glass, and plastic- or rubber-lined pipes and tanks, will allow wider use of ferric chloride. The advantages of ferric chloride are:

1. Compared to alum, only one-half to two-thirds as much ferric chloride is required for coagulation. Although it is currently about twice the price of alum, its cost is competitive;

2. A treatment plant using ferric chloride can be operated at an optimum pH, rather than at a low coagulation pH, which is corrosive. Post-coagulation lime and/or phosphate addition is therefore eliminated, as well as the cathodic protection necessary in alum treatment plants;

3. Ferric chloride is superior to alum for removing undesirable color from water;

4. Storage capacity and O&M allocations are reduced when ferric chloride is used instead of alum.

Preliminary estimates show that ferric chloride may account for 15 to 20 percent of the supply water coagulant market by 1980, reaching sales of between $2 million and $3 million. Total production of ferric chloride may be as high as 280 million pounds by the same year. Chloride is produced by the reaction of metallic iron with recycled ferric chloride to produce ferrous chloride. The ferrous chloride then reacts with chlorine gas to produce chloride. Supply of ferric chloride is not expected to be a problem.

The third class of coagulants considered are the organic polyelectrolytes or synthetic organic polymers. Basically, these polymers are synthesized from monomeric sub-units, many of which may be toxic to humans if ingested in large quantities. Since all polymers carry a certain amount of residual monomer, the distribution of these chemicals must be controlled.

Polyelectrolytes serve three functions in water treatment:

1. As flocculating agents which agglomerate suspended and colloidal materials;

2. As flocculant aids, used in conjunction with inorganic coagulants for greater reduction of turbidity, color, and odor;

3. As filter aids, polyelectrolytes produce stronger flocs than alum or ferric salts, and consequently allow increased flow through filters.

Polymers have the advantage of improving performance while lowering the costs of water clarification. They are generally biodegradable, can be used in small volumes, and are easily incinerated. Furthermore, they are effective under varied pH and temperature conditions. They appear to be cheaper than alum or ferric salts per million gallons of water treated. Upper bounds on treatment costs were estimated at $100/million gallons, with the range of unit costs at $0.40 to $2.50 per pound of solid polymer. Dosages are on the order of 0.1 to 4.0 mg/l for clarification, compared to 5 to 40 mg/l alum, and 3 to 20 mg/l ferric chloride. Projections indicate that 10 to 20 million pounds of polymers will be utilized by the water supply industry by 1980, at a cost of $10 million to $20 million.

Because of changing technologies, prices, and market requirements, there is a shift in the types of coagulants being used. Most experts agree that while the use of both alum and ferric salts will increase during the next decade, the use of organic polymers for coagulation will show an even more dramatic rate of increase. Clarification of community water supplies is expected to account for 25 percent of all coagulants utilized by 1980.

All chemical coagulant manufacturers and suppliers surveyed indicated that there would be essentially no time lag in the delivery of materials due to the sudden demand resulting from the implementation of the Interim Primary Drinking Water Regulations. However, at the time of the survey, most of the major manufacturers contacted were unaware of the impact of the regulations. Rapid growth of the water supply industry's demands for certain chemicals could cause spot shortages of key chemicals if no advance warning is given to the chemical suppliers. However, since it is more than two and one-half years before a treatment system can be designed and constructed, ample time should be available to notify chemical suppliers of the projected chemical demands.

7.1.2 Disinfection

Disinfection is another major treatment process whose increased use is expected to result from the promulgation of the Interim Primary Drinking Water Regulations. It is estimated that approximately 17,260 community systems will require additional disinfection, and that many of the 200,000 non-community suppliers will need biocidal treatment.

Calcium hypochlorite, sodium hypochlorite, and other inorganic chlorine compounds should continue to show a fast growth rate. They should be ideal biocidal agents for non-community water supplies, since they are easily and safely handled in cylinders, pose little threat of rapid dispersal if injected suddenly, and require minimal capital expenditures. Production of hypochlorites is presently at capacity since there is a strong demand for its use as a disinfectant in swimming pools. There are a total of six plants in the United States which produce these chemicals. Consumption of hypochlorites may reach 300 million pounds by 1980, while the total cost of hypochlorites for water treatment is expected to increase an additional $8.2 million by 1980. Occasional delays in shipment may occur until production facilities can be expanded. However, the industry is presently expanding to keep pace with anticipated demands.

7.1.3 Projections

Implementation of the Interim Primary Drinking Water Regulations is expected to place heaviest demands on the coagulant and the disinfectant chemical industries. Projections show that costs for alum, ferric chloride, and hypochlorites will be rising in the near future and that new plants will probably have to be constructed to increase production of calcium hypochlorite. It is generally believed that the raw materials necessary for the manufacture of these chemicals are abundant, and that U.S. self-sufficiency will abate any major problems in the area of treatment chemical supply.

The increasing demand for pollution control chemicals has caused significant price hikes in the last several years, and there is every evidence that this increasing cost trend will continue during the next decade. Table 7-3 shows the projected growth trend for several categories of water treatment chemicals.

7.2 Manpower Constraints

7.2.1 General

Although it provides a universally required product and is the largest industry in the United States, the water supply industry is facing serious problems of manpower both in terms of training and availability. In the present modern, highly urbanized society, water is collected, treated, and delivered in an efficient, reliable manner. This has been made possible through a high degree of functional specialization in the industry's work force, which is estimated to number about 180,000 (exclusive of persons holding similar positions in consulting engineering firms, manufacturing concerns, and government agencies).[1] This level of employment in the water utilities field has been relatively stable for the last 20 years.[2] The industry is currently faced with a growing need for qualified personnel due to (1) increased attention to ecological and consumer issues, (2) more stringent legal requirements for water product quality, (3) rising public demands for better quality water, and (4) technological improvements in the design and operation of water supply facilities. However, the industry has

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[1] H.E. Hudson and F. Rodriguez, "Water Utility Personnel Statistics," JAWWA, 62: 8, 1970.

[2] C.M. Schwig, "Training and Recruiting of Water Utility Personnel," JAWWA, 66: 7, 1974.

TABLE 7-3

WATER AND WASTEWATER TREATMENT CHEMICALS[a]

ITEM	1970	1980	ANNUAL PERCENT CHANGE 1970-80
MILLION POUNDS			
Coagulants	1,326	2,085	4.6
Filter Media	556	926	5.2
pH neutralizers and Salt	5,950	11,925	7.2
Biologicals	993	4,427	16.2
Internal Preparations	484	870	6.1
Total Volume	9,309	20,233	8.1
Cents per Pound	4.1	4.7	1.4
MILLION DOLLARS			
Coagulants	56.7	126.0	7.6
Filter Media	48.0	115.9	9.2
pH Neutralizers and Salt	64.6	152.8	9.0
Biologicals	71.9	200.4	10.8
Internal Preparations	143.0	348.0	9.3
Total Value	384.2	943.1	9.4
Industrial and municipal Water Consumption (Tgal)	95.6	146	4.3
Lb/M gal	97	139	3.6
Gross National Product ($ billion)	974	1,900	6.9
Antipollution Chemical Sales/$000 GNP	0.39	0.50	2.5

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[a] A.C. Gross "Markets for Chemicals Grow and Grow," _Environmental Science and Technology_, (8)5: 1974, p. 414.

historically had trouble attracting and retaining technically trained personnel due to low wages, salaries, and benefits paid to water utility personnel.[1]

7.2.2 Manpower Availability

The industry needs more managers, engineers, chemists, biologists, and other professional persons to fill technical positions. In addition, the level of expertise of non-technical personnel must be increased through training and advancement incentives.

Despite high national unemployment rates, the reservoir of unemployed manpower does not include many people required by the water supply industry today.[2] The industry's greatest need is for civil, sanitary, and chemical engineers who, as a group, have the lowest incidence of unemployment among engineers. Professionally trained engineers are not needed for every manpower deficit, however. In fact, a major element in the solution of manpower problems would be the better utilization of available manpower. Babcock[3] points out that highly technically trained people are not needed in some of the middle levels of water supply systems and that sources of adequate personnel include (1) junior colleges and universities, (2) training schools, (3) transfers from industry, and (4) in-house advancement. He further notes that "...a successful key to any recruiting program is to campaign at all levels actively, by all people, to bring the salary levels of personnel to reasonable values."[4]

7.2.3 Personnel Required to Implement Interim Primary Drinking Water Regulations

This section estimates the manpower necessary to implement the Interim Primary Drinking Water Regulations.

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[1] G.H. Dyer, "Recruiting and Holding Good Employees: Employee Grievance Procedures, JAWWA, 62: 8, 1970.

[2] G.H. Dyer, "Manpower: The Important Element in Providing Quality Water Service," JAWWA, 66, 1974.

[3] R.H. Babcock, "Recruiting - A Proposal for Action," JAWWA, 66: 7, 1974.

[4] Babcock, "Recruiting - A Proposal for Action," 1974.

The responsibilities for this implementation would encompass all levels of government, Federal, state and local, and many diverse categories of both basic and support services. Of primary concern are the personnel requirements for (1) monitoring and enforcement, (2) operation of process equipment, and (3) program administration and assistance.

Additional manpower will be needed for the routine microbiological and chemical monitoring and analysis required by the Interim Primary Drinking Water Regulations. The microbiological manpower requirement is outlined in Table 7-4, while Table 7-5 gives a breakdown of laboratory manpower requirements for chemical monitoring for community systems and for non-community systems. It is assumed that no manpower is presently employed in performing the chemical analyses required by the regulations.

State surveillance of drinking water systems is an additional component of the monitoring and surveillance costs. Jeffrey estimates that four man-days of field time per system are required annually to accomplish this task for community systems.[1] This amounts to 160,000 man-days or 727.3 man-years to examine all community drinking water systems.

Routine monitoring of water supplies will identify those systems exceeding one or more maximum contaminant levels. These systems will be required to install treatment instrumentation, which will, in turn, require additional operational personnel. The exact manpower requirements will vary from system to system, depending on the sophistication of the equipment and the amount of production. For example, chlorination units need a minimum of daily surveillance; ion exchange needs daily surveillance, backwash, and either regeneration or replacement. The total estimated manpower required is 34,318 man-years (Table 7-6).

Program administration is the final key element in effective implementation of the Interim Primary Drinking Water Regulations. This segment can be broken down into

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[1] E.A. Jeffrey, "Water Supply Training and Manpower Needs," Journal of New England Water Works Association (Washington, D.C., June 1972).

TABLE 7-4

MICROBIOLOGICAL STAFFING REQUIREMENTS

POPULATION RANGE	AVERAGE POPULATION SERVED[a]	NUMBER OF SYSTEMS	NUMBER OF COLIFORM ANALYSES[b] (1,000)	MANPOWER REQUIREMENT[c] (man-years) (220 days/year)
25-99	60	7,008	84	23.9
100-499	250	15,113	182	51.7
500-999	700	5,392	64	18.2
1,000-2,499	1,500	5,182	124	35.2
2,500-4,999	3,400	2,605	125	35.5
5,000-9,999	6,800	1,858	178	50.6
10,000-99,999	23,633	2,599	956	271.6
100,000-999,999	242,700	236	391	d
≥1,000,000	3,074,800	7	37	d
		40,000		486.7
NON-COMMUNITY SYSTEMS		200,000	800,000	227.3
ADDITIONAL MANPOWER REQUIRED:				714.0

[a] Assuming present average population in nine population ranges.

[b] Use required number of analyses per population served.

[c] Assume 0.5 man-hours per sample. This includes sample collection, analysis, and reporting.

[d] Assume this monitoring is presently being done.

TABLE 7-5

LABORATORY MANPOWER REQUIREMENTS -- NATIONWIDE MONITORING FOR COMMUNITY AND NON-COMMUNITY WATER SYSTEMS

COMPONENT	ANALYSIS[a,b] MAN-YEAR	ANALYSES[c] REQUIRED NATIONWIDE FIRST TWO YEARS			------THIRD YEAR------			MAN YEARS OF ANALYTICAL EFFORT		
		Routine	Violator[d]	Total	Routine	Violator[d]	Total	FIRST	SECOND	THIRD
As	4,400	25,100	196	25,296	20,200		20,200	5.7	5.7	4.6
Ba	6,600	25,100	266	25,166	20,200		20,200	3.8	3.8	3.1
Cd	2,200	25,100	262	25,362	20,200		20,200	11.5	11.5	9.2
Cr	6,600	25,100	196	25,296	20,200		20,200	3.8	3.8	3.1
F	6,600	25,100	2,344	27,444	20,200		20,200	4.2	4.2	3.1
Pb	2,200	25,100	393	25,493	20,200		20,200	11.6	11.6	9.2
Hg	4,400	25,100	724	25,824	20,200		20,200	5.9	5.9	4.6
NO_3	6,600	25,100	1,453	26,553	20,200		20,200	4.0	4.0	3.1
Se	4,400	25,100	559	25,659	20,200		20,200	5.8	5.8	4.6
Ag	6,600	25,100		25,100	20,200		20,200	3.8	3.8	3.1
Pesticides & Herbicides	198	25,100		25,100	20,200		20,200	126.8	126.8	102.0
		SUBTOTAL COMMUNITY MONITORING MANPOWER REQUIREMENTS						186.9	186.9	149.7
NO_3					33,333	3,099		-	-	5.5
		SUBTOTAL NON-COMMUNITY MONITORING MANPOWER REQUIREMENTS						-	-	5.5
							TOTAL	186.9	186.9	155.2

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[a] Personal communication with E. McFarren and H. Nash, EPA Cincinnati, June 1975.

[b] Personal communication with J. Dice, Denver Board of Water Commissioners, March 1975.

[c] Estimates based on 1969 study.

[d] Assuming an average of 3 analyses for each violation.

TABLE 7-6

PERSONNEL REQUIRED TO OPERATE NEW AND RETROFIT PROCESS EQUIPMENT

TREATMENT	NUMBER OF ADDITIONAL SYSTEMS	EMPLOYEES PER SYSTEM (man-years)	TOTAL ADDITIONAL TREATMENT PERSONNEL NEEDED
Chlorination	17,262	0.5	8,631
Clarification	2,143	5	10,715
Ion Exchange	2,518	1	2,518
Activated Alumina	1,554	1	1,554
pH Control	673	1	673
Total additional process personnel required for community systems			24,091
Total additional process personnel required for public non-community systems			10,227[a]
TOTAL			34,318

[a] Assumes one-fourth of 200,000 systems require some minimal treatment for 45 man-days per year.

management, planning, and public information. Table 7-7 shows the total administrative manpower required for implementation.

Eighty-one percent of the personnel required to implement the regulations are process personnel who would run the treatment plants at the local level. The demand for these process employees is expected to begin in 1979 and one-fifth of the total number would be employed each succeeding year for 5 years. The 2.6 percent of the personnel involved in monitoring and 3.0 percent involved in surveillance would be required by July 1976; the remaining personnel would be employed between 1976 and 1984.

TABLE 7-7

SUMMARY OF MANPOWER REQUIRED TO IMPLEMENT THE INTERIM PRIMARY DRINKING WATER REGULATIONS

FUNCTION	STATE	LOCAL (man-years)	FEDERAL	TOTAL
MONITORING				
microbiological[a]	536	178	0	714
chemical[a]	116	39	0	155
turbidity	0	226	0	226
surveillance	959	0	319	1,278
PROCESS OPERATION	0	34,318	0	34,318
PROGRAM ASSISTANCE	282	0	94	376
CLERICAL[b]	416	784	91	1,291
PROGRAM ADMINISTRATION[c]	189	3,476	41	3,706
TOTAL	2,498	39,021	545	42,064

[a] Assumes that the State will do three-fourths of the monitoring and that local agencies will do one-fourth.

[b] Assumes one clerical person for every five non-process personnel.

[c] Assumes one administrator for every ten non-clerical personnel.

7.3 Laboratory Constraints

The availability of laboratory facilities which have been certified by the states is one of the factors which will determine the success of the monitoring required under the Interim Primary Drinking Water Regulations.

Table 7-8 shows the number of laboratories presently certified to perform inorganic, bacteriological, and turbidity analyses. The state-by-state information in this table is from a survey taken by the project staff.[1] At the present time no state has an active certification program which would enable rapid compliance with Section 141.28 of the interim regulations. It is possible, however, that many states will be able to certify a sufficient number of laboratories before the effective date of the regulations.

As part of the effort made to determine laboratory availability, the amount of coliform testing presently being done was determined. The compliance schedules for selected food industries and municipal wastewater treatment facilities were examined. The monitoring frequencies, number of plants, and number of coliform analyses presently being performed are listed in Table 7-9, as is the additional coliform monitoring required by the Interim Primary Drinking Water Regulations. This additional monitoring is approximately 15 percent of the total presently being done in the industries examined. It is anticipated that the private sector could supply ample facilities to handle the increased laboratory load, if economic incentives justify the expansion of existing facilities.

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[1] The results of this survey are in Appendix C of this report.

TABLE 7-8

LAB CERTIFICATION BY STATE

	INORGANIC				BACTERIOLOGICAL				TURBIDITY	RESIDUAL CHLORINE
	In-House	Pri.	Mun.	St.	In-House	Pri.	Mun.	St.		
ALABAMA										
ALASKA	N	N	N	N	N	N	N	N	NO	NO
ARIZONA	N	N	N	1	N	N	N	N	NO	NO
ARKANSAS										
CALIFORNIA	101	107	88	3	33		160	21	NO	NO
COLORADO										
CONNECTICUT										
DELAWARE										
DISTRICT OF COLUMBIA										
FLORIDA	N	N	N	N	N	N	N	7	NO	NO
GEORGIA	N	N	N	N	N	N	N	N	NO	NO
HAWAII	1	N	N	1	1	N	N	4	NO	NO
IDAHO	N	N	N	1	N	1	N	5	NO	NO
ILLINOIS	N	N	N	N	15	9	14	7	NO	NO
INDIANA	N	N	N	N	30	17	3	N	NO	NO
IOWA	N	N	N	1	N	3	18	2	NO	NO
KANSAS	N	N	N	N	5	N	2	N	NO	NO
KENTUCKY	N	N	N	N	15	3	4	2	NO	NO
LOUISIANA										
MAINE	N	N	N	N	5	2	N	1	NO	YES
MARYLAND	N	N	N	N	10	0	0	9	NO	NO
MASSACHUSETTS										
MICHIGAN	N	N	N	N	107	2	N	4	NO	YES
MINNESOTA										
MISSISSIPPI										
MISSOURI										
MONTANA	-	-	-	-	-	-	-	-	-	-
NEBRASKA	1	N	3	3	1	N	3	3	NO	NO
NEVADA										
NEW HAMPSHIRE										
NEW JERSEY	N	N	N	N	33*	31*	9	N	NO	NO
NEW MEXICO	N	N	N	1	N	N	N	1	NO	NO
NEW YORK										
NORTH CAROLINA	16	N	2	1	16	N	2	1	NO	NO
NORTH DAKOTA	N	N	N	N	3	N	1	6	NO	NO
OHIO	2	N	N	1	147	22	N	22	YES	YES
OKLAHOMA	50	N	100	1	4	N	4	1	NO	NO
OREGON										
PENNSYLVANIA	N	N	N	N	80	185	80	3		
RHODE ISLAND	N	N	N	N	8	5	N	3	NO	NO
SOUTH CAROLINA	113	1	N	1	78	1	N	5	YES	YES
SOUTH DAKOTA									NO	NO
TENNESSEE										
TEXAS	N	N	N	N	46	N	N	26	NO	NO
UTAH	N	4	N	1	N	1	5	1	NO	NO
VERMONT	N	N	N	N	N	N	N	N	YES	YES
VIRGINIA										
WASHINGTON	N	N	N	N	5	4	17	1	NO	NO
WEST VIRGINIA										
WISCONSIN										
WYOMING	N	N	N	N	1	1	1	1	NO	NO

*46 in-house, private are uncertified.

N means no answer.
No entry indicates lack of response.

TABLE 7-9

PRESENT COLIFORM MONITORING TO MEET EFFLUENT GUIDELINE LIMITATION REGULATIONS

INDUSTRY	SAMPLING FREQUENCY	NUMBER OF PLANTS	NUMBER OF COLIFORM ANALYSES PRESENTLY PERFORMED/YEAR
FOOD PRODUCTS[a]			
1-10 mgd	one per week	4,000	208,000
10-50 mgd	three times per week	550	85,800
WASTEWATER TREATMENT			
<0.99 mgd	one per month	16,200	194,400
1-4.99 mgd	one per week	10,200	530,400
5-14.99 mgd	five times weekly	3,600	936,000
TOTAL			1,954,600
Projected coliform monitoring requirement to implement Interim Primary Drinking Water Regulations for community water supplies			2,547,397
Present coliform monitoring being done for community water supplies			1,961,621
Additional coliform monitoring mandated by Interim Primary Drinking Water Regulations			585,776

[a] Marketing Economics Institute, Limited., Marketing Economics Industry Key Plants, 1973; includes plants employing over 100 people.

CHAPTER EIGHT

LIMITS OF THE ANALYSIS

8.0 Introduction

This chapter is a review of the major assumptions used in developing costs in this report. The dominant assumption used in developing costs is that the EPA inventory of community water systems provides an accurate description of the population of drinking water supplies in the United States. There is some evidence, however, that the inventory's estimate of 40,000 community systems is low by a factor of 20 percent, thereby causing some of the projected costs to be low by 20 percent as well.

The EPA estimate of 200,000 public non-community systems is also accepted as valid in this study. No conclusive evidence has been determined which either confirms or refutes this estimate.

8.1 Assumptions in Developing Monitoring Costs

The monitoring costs developed were based on the assumption that only the minimal routine monitoring required by the Interim Primary Drinking Water Regulations would be performed. It is quite possible that many systems, particularly those systems with chemical and biological laboratories, will choose to sample at a more frequent rate than that indicated in the regulations. Until a more complete data base is developed, it is impossible to predict the number of systems which will perform more than the minimal amount of sampling, to assure compliance with the regulations.

Special monitoring and treatment costs were all developed from the 1969 CWSS study of 969 water supply plants. The CWSS study has several inherent biases which are magnified in projecting special national monitoring costs. This is due to the fact that the systems studied were not chosen at random; rather, they were chosen to represent specific water source characteristics in nine regions of the country.

This report made no estimate of the costs of turbidity monitoring for the 40,000 community systems and the 2,000 to 5,000 public non-community systems which will need to measure turbidity in order to comply with the Interim Primary Drinking Water Regulations. It was assumed that turbidity sampling is presently being performed at each site. It is useful, however, to examine the costs of this monitoring activity. If one assumes that it takes 10 minutes to collect and analyze each turbidity sample, then 505 man-years of effort would be required nationally to satisfy the turbidity monitoring requirement. Given a salary of $4.00 per hour and an overhead rate of 100 percent, labor alone would cost $1.33 per turbidity analysis.

8.2 Assumptions in Developing Treatment Costs

The assumptions about the number of systems and the validity of the CWSS data base, as developed in the previous section, are equally important in this section.

EPA personnel developed the assumptions which were used in preparing estimates of the total national treatment costs due to the implementation of the interim regulations. These assumptions are:

1. Disinfection equipment will be installed in 27.5 percent of community surface and ground systems in the EPA Inventory of Community Water Supplies which do not presently disinfect. This percentage was derived by assuming that 15 percent of the systems analyzed the first year are expected to fail to meet the coliform requirement, and that 15 percent of the remainder are expected to fail during the second year;

2. All community surface systems in the EPA inventory which do not presently clarify will be forced to install clarification equipment;

3. All systems which violated one or more maximum contaminant level (MCL) in the 1969 CWSS study will treat their water; furthermore, the systems of the CWSS are considered representative of the nation's water systems.

Based on these assumptions, the $1.1 billion to $1.8 billion capital requirement developed represents the cost of reaching the goal of the Safe Drinking Water Act.

There are several reasons why the $1.1 billion to $1.8 billion capital requirement estimated to implement the Interim Primary Drinking Water Regulations may be conservative. In calculating the treatment costs for turbidity control, direct filtration was chosen as the most suitable technology. Direct filtration is a reasonable treatment for those systems with turbidity under 100 JTU, but it is not a practical treatment to use if the turbidity of the water is consistently above this level or if significant seasonal variations in turbidity exist. Therefore, it is highly likely that many systems may choose to install the more expensive process of coagulation, sedimentation, and filtration, which assures more uniform quality effluent during periods of high turbidity. The capital and annual O&M expenses calculated for turbidity control using direct filtration versus coagulation, sedimentation, and filtration are shown in Table 8-1.

TABLE 8-1

COMPARISON OF TURBIDITY CONTROL COSTS PER SYSTEM IN EACH OF NINE POPULATION SERVED CATEGORIES

POPULATION SERVED	CLARIFICATION COSTS ASSUMING COAGULATION, SEDIMENTATION, AND FILTRATION ($)	CLARIFICATION COSTS ASSUMING DIRECT FILTRATION ($)
25-99	220,000	21,000
100-499	300,000	30,000
500-999	370,000	41,000
1,000-2,499	430,000	52,000
2,500-4,999	480,000	150,000
5,000-9,999	530,000	270,000
10,000-99,999	1,400,000	640,000
100,000-999,999	7,200,000	3,400,000
≥1,000,000	41,000,000	22,000,000

In developing the national capital cost estimates, no attempt was made to assign turbidity control costs to the 1,366 mixed surface and ground systems. If a mixed source system obtains the majority of its water from a surface source, then it is probable that some form of clarification will be required.

For the purpose of this study, it was assumed that only 27.5 percent of the water systems not presently chlorinating would need to disinfect their water supplies; this includes both surface and ground source of water. It is possible that more systems may need some form of disinfection to meet the coliform standards.

There are several reasons why the projected capital requirement may be high. One important assumption is that systems which exceed a maximum contaminant level will use a treatment process to correct their problem, when in reality a great number of plants will blend water which meets the standards with water which exceeds the standards. Blending would reduce the costs to those systems which must treat for NO_3, Se, Cd, Cr, As, Hg, and Ba violations, but it would not affect costs associated with chlorination and clarification. In a 1975 project survey of 207 water supply systems which violated one or more maximum contaminant level in the 1969 CWSS study, it was found that five systems had begun treating for NO_3 and Se problems subsequent to the 1969 CWSS study (see Appendix H, Table H-2). All five of these systems used blending rather than the more expensive ion exchange treatment. Since ion exchange processes account for almost 35 percent of the total treatment costs, the use of blending could substantially reduce the total national treatment costs.

The possibility of savings to be derived from the cascading of treatment processes was not considered in the development of treatment costs. With the limited data available, it is impossible to quantify the benefits of cascading. There are many cases, however, in which it is possible to treat several contaminants at once, thereby reducing costs. In particular, coagulation and direct filtration may remove many contaminants which are not associated with turbidity. It is also impossible to quantify any beneficial effects attributable to the retrofitting of treatment processes. Since it was assumed that there are 2,126 water systems which would install clarification equipment, retrofitting could reduce costs substantially for these systems.

In developing the treatment costs, it became apparent that considerable attention should be given to the costs which would be borne by small (under 1,000 population served) water systems. Table 8-2 lists the capital costs associated with each treatment technology for the systems serving 1,000 or fewer people. When one examines the capital costs for clarification and ion exchange for small systems, it is apparent that the per capita burden of treatment is too great for any community to bear. The small systems in particular would probably consider the following options, rather than install expensive treatment processes:

1. Shift the source of water from surface to ground;
2. Change groundwater sources;
3. Consolidate (merge systems);
4. Purchase finished water;
5. Disband the community system and change to individual well sources.

TABLE 8-2

CAPITAL TREATMENT COSTS FOR SMALL WATER SYSTEMS[a] USING CURRENT AVERAGE DAILY PRODUCTION RATES

POPULATION SERVED CATEGORY	DISINFECTION	CLARIFICATION	ION EXCHANGE	pH CONTROL	ACTIVATED ALUMINA
25-99	699	21,000	41,000	400	2,600
100-499	1,200	30,000	68,000	800	6,100
500-999	1,800	41,000	100,000	1,200	12,000
1,000-2,499	2,500	52,000	140,000	2,500	22,000

[a] Based on average sized systems in the EPA Inventory of Community Water Supplies.

Table 8-3 shows the total national costs to small community systems of applying the recommended treatment technologies to comply with the Interim Primary Drinking Water Regulations. It is apparent that many of these costs will not, in fact, be spent on treating these small systems. What is not known, however, is the number of systems which will purchase water from existing systems, thereby increasing treatment costs for those systems. Until these two factors can be determined, it appears reasonable to assign the costs to small systems, even though they may not ultimately treat their present source of water.

TABLE 8-3

ION EXCHANGE AND CLARIFICATION COSTS ASSIGNED TO SMALL COMMUNITY SYSTEMS

POPULATION SERVED CATEGORY	CLARIFICATION COSTS ($ 1,000)	ION EXCHANGE COSTS ($ 1,000)	SUM OF CLARIFICATION & ION EXCHANGE TOTAL COSTS ($ 1,000)
25-99	5,292	19,926	25,218
100-499	19,590	67,728	87,318
500-999	12,013	33,700	45,713
1,000-2,499	19,656	42,140	61,796
TOTAL SMALL SYSTEM COST	56,551	163,494	220,045
TOTAL NATIONAL TREATMENT COST	379,371	619,204	998,575
PERCENT OF TOTAL NATIONAL TREATMENT COSTS	14.9	26.4	22.1

8.3 Assumptions Inherent in the Constraint Analysis

It is assumed that in the coming decade the demand for polyelectrolytes will increase markedly as these chemicals replace inorganic salts as the most widely used coagulants.

The constraint analysis also rests on the assumption that manpower needs will increase dramatically for monitoring and treatment process operations. Historically, water systems have had trouble attracting and retaining qualified personnel.

8.4 Other Assumptions

To simplify the analysis of the aggregate impact under the interim primary regulations, an interest rate of 7 percent has been designated as the cost of financing for an average water system. A second simplifying assumption was that a 15-year pay back period would be used to finance the costs. As mentioned earlier, small investor-owned facilities are riskier than large government-owned operations. The cost of money to the former is correspondingly higher than to the latter. Tables 8-4, 8-5, and 8-6 break down the per capita impacts of these different financing costs according to utility size and treatment process. Measured only against the costs of new plant and equipment, financing charges and pay back period differences are not insignificant. When all costs are considered, however, the per capita impact of different interest rates is less noticeable, since the majority of annual expenditures go into O&M costs rather than financing charges. No assumption is made on the rate of inflation which will occur in the coming decade. All costs are based on 1975 dollars with no factor for inflation.

TABLE 8-4

PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 100 PEOPLE[a]

PROCESS	CAPITAL[b] COST ($)	INTEREST[c] RATE	ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD			ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD		
			15 YRS	20 YRS	25 YRS	15 YRS	20 YRS	25 YRS
Chlorination	810	11	138	121	119	1.38	1.21	1.19
		9	121	113	105	1.21	1.13	1.05
		7	113	97	93	1.13	0.97	0.93
Clarification	23,500	11	3,910	3,687	3,471	39.10	36.87	34.71
		9	3,567	3,243	3,074	35.67	32.43	30.74
		7	3,241	2,890	2,700	32.41	28.90	27.00
Ion Exchange	48,000	11	7,987	7,387	7,090	79.87	73.87	70.90
		9	7,286	6,624	6,278	72.86	66.24	62.78
		7	6,619	5,904	5,515	66.19	59.04	55.15
Activated Alumina	3,400	11	566	523	502	5.66	5.23	5.02
		9	516	469	445	5.16	4.69	4.45
		7	469	419	391	4.69	4.19	3.91
pH Control	810	11	138	121	119	1.38	1.21	1.19
		9	121	113	105	1.21	1.13	1.05
		7	113	97	93	1.13	0.97	0.93

[a] Assumes only residential use.

[b] Based on 109 gallons (0.412 m^3) produced per consumer per day.

[c] Does not include the 3 percent for insurance, taxes, etc., which is applied to determine the annual capital costs.

TABLE 8-5

PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 5,000 PEOPLE[a]

PROCESS	CAPITAL[b] COST ($)	INTEREST[c] RATE	ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD 15 YRS	20 YRS	25 YRS	ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD 15 YRS	20 YRS	25 YRS
Chlorination	10,000	9	1,518	1,379	1,313	0.30	0.27	0.26
		7	1,380	1,231	1,160	0.28	0.25	0.23
		6	1,308	1,149	1,074	0.26	0.23	0.21
Clarification	220,000	9	33,396	30,360	28,776	6.68	6.08	5.75
		7	30,338	27,060	25,278	6.08	5.41	5.06
		6	28,886	25,520	23,628	5.78	5.10	4.73
Ion Exchange	660,000	9	100,188	91,030	86,328	20.04	18.20	17.27
		7	91,014	81,180	75,834	18.20	16.24	15.17
		6	86,658	76,560	70,884	17.33	15.31	14.18
Activated Alumina	50,000	9	7,590	6,900	6,540	1.52	1.38	1.31
		7	6,895	6,155	5,745	1.38	1.23	1.15
		6	6,565	5,850	5,370	1.31	1.16	1.07
pH Control	10,000	9	1,518	1,379	1,313	0.30	0.27	0.26
		7	1,380	1,231	1,160	0.28	0.25	0.23
		6	1,308	1,149	1,074	0.26	0.23	0.21

[a] Assumes only residential use.

[b] Based on 154 (0.582 m^3) produced per consumer per day.

[c] Does not include the 3 percent for insurance, taxes, etc., which is applied to determine the annual capital costs.

TABLE 8-6

PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 100,000 PEOPLE[a]

PROCESS	CAPITAL COST ($)[b]	INTEREST RATE[c]	ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD 15 YRS	20 YRS	25 YRS	ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD 15 YRS	20 YRS	25 YRS
Chlorination	100,000	9	15,180	13,790	13,130	0.15	0.14	0.13
		7	13,800	12,310	11,600	0.14	0.12	0.12
		6	10,080	8,490	7,740	0.10	0.08	0.08
Clarification	1,900,000	9	288,420	262,200	248,520	2.88	2.62	2.49
		7	262,010	233,890	218,310	2.62	2.34	2.18
		6	249,470	220,400	204,060	2.49	2.20	2.04
Ion Exchange	5,800,000	9	880,440	800,400	758,640	8.80	8.00	7.59
		7	799,820	713,980	666,420	8.00	7.14	6.66
		6	761,540	672,800	622,920	7.61	6.72	6.23
Activated Alumina	350,000	9	53,130	48,300	45,780	0.53	0.48	0.46
		7	48,265	43,085	40,615	0.48	0.43	0.40
		6	45,955	40,600	37,590	0.46	0.41	0.38
pH Control	100,000	9	15,180	13,790	13,130	0.15	0.14	0.13
		7	13,800	12,310	11,600	0.14	0.12	0.12
		6	10,080	8,490	7,740	0.10	0.08	0.08

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[a] Assumes only residential use.

[b] Based on 174 gallons (0.658 m^3) produced per consumer per day.

[c] Does not include the 3 percent for insurance, taxes, etc., which is applied to determine the annual capital costs.

APPENDIX A

NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

SUBCHAPTER D -- WATER PROGRAMS

PART 141 -- NATIONAL INTERIM PRIMARY DRINKING WATER REGULATIONS

Subpart A - General

Sec.

141.1 Applicability.
141.2 Definitions.
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141.21 Microbiological contaminant sampling and analytical requirements.
141.22 Turbidity sampling and analytical requirements.
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141.24 Organic chemical sampling and analytical requirements.
141.27 Alternative analytical techniques.
141.28 Approved laboratories.
141.29 Monitoring of consecutive public water systems.

Subpart D - Reporting, Public Notification, and Recordkeeping

141.31 Reporting requirements.
141.32 Public notification of variances, exemptions, and non-compliance with regulations.
141.33 Record maintenance.

Authority: Secs. 1412, 1414, 1445, and 1450 of the Public Health Service Act, 88 Stat. 1660 (42 U.S.C. 300g-1, 300g-3, 300j-4, and 300j-9).

Subpart A - General

Section 141.1. Applicability.

This part establishes primary drinking water regulations pursuant to section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93-523); and related regulations applicable to public water systems.

Section 141.2. Definitions.

As used in this part, the term:

(a) "Act" means the Public Health Service Act, as amended by the Safe Drinking Water Act, Pub. L. 93-523.

(b) "Contaminant" means any physical, chemical, biological, or radiological substance or matter in water.

(c) "Maximum contaminant level" means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by of the user, except those resulting from corrosion

of piping and plumbing caused by water quality, are excluded from this definition.

(d) "Person" means an individual, corporation, company, association, partnership, State, municipality, or Federal agency.

(e) "Public water system" means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least 60 days out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. A public water system is either a "community water system" or a "non-community water system."

(1) "Community water system" means a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

(2) "Non-community water system" means a public water system that is not a community water system.

(f) "Sanitary survey" means an on-site review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(g) "Standard sample" means the aliquot of finished drinking water that is examined for the presence of coliform bacteria.

(h) "State" means the agency of the State government which has jurisdiction over public water systems. During any period when a State does not have primary enforcement responsibility, pursuant to Section 1413 of the Act, the term "State" means the Regional Administrator, U.S. Environmental Protection Agency.

(i) "Supplier of water" means any person who owns or operates a public water system.

Section 141.3 Coverage

This part shall apply to each public water system, unless the public water system meets all of the following conditions:

(a) Consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(b) Obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(c) Does not sell water to any person; and

(d) Is not a carrier which conveys passengers in interstate commerce.

Section 141.4 Variances and exemptions

Variances or exemptions from certain provisions of these regulations may be granted pursuant to Sections 1415 and 1416 of the Act by the entity with primary enforcement responsibility. Provisions under Part 142, National Interim Primary Drinking Water Regulations Implementation-subpart E (Variances) and subpart F (Exemptions)-apply where EPA has primary enforcement responsibility.

Section 141.5 Siting requirements

Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall notify the State and, to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(a) Is subject to significant risk from earthquakes, floods, fires or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(b) Except for intake structures, is within the floodplain of a 100-year flood or is lower than any recorded high tide where appropriate records exist.

The U.S. Environmental Protection Agency will not seek to override land use decisions affecting public water system siting which are made at the State or local government levels.

Section 141.6 Effective date

The regulations set forth in this part shall take effect 18 months after the date of promulgation.

Subpart B - Maximum Contaminant Levels

Sec. 141.11 Maximum contaminant levels for inorganic chemicals.

(a) The maximum contaminant level for nitrate is applicable to both community water systems and non-community water systems. The levels for the other inorganic chemicals apply only to community water systems. Compliance with maximum contaminant levels for inorganic chemicals is calculated pursuant to § 141.23.

(b) The following are the maximum contaminant levels for inorganic chemicals other than fluoride:

Contaminant	Level (mg/l)
Arsenic	0.05
Barium	1.
Cadmium	0.010
Chromium	0.05
Lead	0.05
Mercury	0.002
Nitrate (as N)	10.
Selenium	0.01
Silver	0.05

(c) When the annual average of the maximum daily air temperatures for the location in which the community water system is situated is the following, the maximum contaminant levels for fluoride are:

Temperature (in degrees F)	(degrees C)	Level (mg/l)
53.7 and below	12.0 and below	2.4
53.8 - 58.3	12.1-14.6	2.2
58.4 - 63.8	14.7-17.6	2.0
63.9 - 70.6	17.7-21.4	1.8
70.7 - 79.2	21.5-26.2	1.6
79.3 - 90.5	26.3- 32.5	1.4

Section 141.12 Maximum contaminant levels for organic chemicals.

The following are the maximum contaminant levels for organic chemicals. They apply only to community water systems. Complaince with maximum contaminant levels for organic chemical is calculated pursuant to § 141.24.

(a) Chlorinated Hydrocarbons	Level mg/l
Endrin (1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5, 8-dimethano naphthalene)	0.0002
Lindane (1, 2, 3, 4, 5, 6-Hexachloro-cyclohexane, gamma isomer)	0.004
Methoxychlor (1, 1, 1-Trichloro-2, 2-bis [p-methoxyphenyl] ethane)	0.1
Toxaphene ($C_{10}H_{10}Cl_8$ - Technical chlorinated camphene, 67-69% chlorine)	0.005
(b) Chlorophenoxys	
2, 4-D (2, 4-Dichlorophenoxyacetic acid)	0.1
2, 4, 5-TP Silvex (2, 4, 5-Trichlorophenoxypropionic acid)	0.01

Section 141.13 Maximum contaminant levels for turbidity.

The maximum contaminant levels for turbidity are applicable to both community water systems and non-community water systems using surface water sources in whole or in part.

The maximum contaminant levels for turbidity in drinking water, measured at a representative entry point(s) to the distribution system, are:

a) One turbidity unit (TU), as determined by a monthly average pursuant to § 141.22, except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not do any of the following;

(1) Interfere with disinfection;

(2) Prevent maintenance of an effective disinfectant agent throughout the distribution system; or

(3) Interfere with microbiological determinations.

(b) Five turbidity units based on an average for two consecutive days pursuant to §141.22.

Section 141.14 Maximum microbiological contaminant levels.

The maximum contaminant levels for coliform bacteria, applicable to community water systems and non-community water systems, are as follows:

(a) When the membrane filter technique pursuant to §141.21(a) is used, the number of coliform bacteria shall not exceed any of the following:

(1) One per 100 milliliters as the arithmetic mean of all samples examined per month pursuant to § 141.21 (b) or (c);

(2) Four per 100 milliliters in more than one sample when less than 20 are examined per month; or

(3) Four per 100 milliliters in more than five percent of the samples when 20 or more are examined per month.

(b)(1) When the fermentation tube method and 10 milliliter standard portions pursuant to § 141.21(a) are used, coliform bacteria shall not be present in any of the following:

(i) more than 10 percent of the portions in any month pursuant to § 141.21 (b) or (c);

(ii) three or more portions in more than one sample when less than 20 samples are examined per month; or

(iii) three or more portions in more than five percent of the samples when 20 or more samples are examined per month.

(2) When the fermentation tube method and 100 milliliter standard portions pursuant to § 141.21(a) are used, coliform bacteria shall not be present in any of the following:

(i) more than 60 percent of the portions in any month pursuant to § 141.21 (b) or (c);

(ii) five or more portions in more than one sample when less than five samples are examined per month; or

(iii) five or more portions in more than 20 percent of the samples when five or more samples are examined per month.

(c) For community or non-community systems that are required to sample at a rate of less than 4 per month, compliance with paragraphs (a), (b)(1), or (b)(2) shall be based upon sampling during a 3 month period, except that, at the discretion of the State, compliance may be based upon sampling during a one-month period.

Subpart C - Monitoring and Analytical Requirements

Section 141.21 Microbiological contaminant sampling and analytical requirements.

(a) Suppliers of water for community water systems and non-community water systems shall analyse for coliform bacteria for the purpose of determining compliance with § 141.14. Analyses shall be conducted in accordance with the analytical recommendations set forth in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 13th Edition, pp 662-688, except that a standard sample size shall be employed. The standard sample used in the membrane filter procedure shall be 100 milliliters. The standard sample used in the 5 tube must probable number (MPN) procedure (fermentation tube method) shall be 5 times the standard portion. The standard portion is either 10 milliliters or 100 milliliters as described in § 141.14 (b) and (c). The samples shall be taken at points which are representative of the conditions within the distribution system.

(b) The supplier of water for a community water system shall take coliform density samples at regular time intervals, and in number proportionate to the population served by the system. In no event shall the frequency be less than as set forth below:

Population Served	Minimum Number of Samples Per Month
25 - 1,000	1
1,001 - 2,500	2
2,501 - 3,300	3
3,301 - 4,100	4
4,101 - 4,900	5
4,901 - 5,800	6
5,801 - 6,700	7
6,701 - 7,600	8
7,601 - 8,500	9
8,501 - 9,400	10
9,401 - 10,300	11
10,301 - 11,100	12
11,101 - 12,000	13
12,001 - 12,900	14
12,901 - 13,700	15
13,701 - 14,600	16
14,601 - 15,500	17
15,501 - 16,300	18
16,301 - 17,200	19
17,201 - 18,100	20
18,101 - 18,900	21
18,901 - 19,800	22

Population Served	Minimum Number of Samples Per Month
19,801 - 20,700	23
20,701 - 21,500	24
21,501 - 22,300	25
22,301 - 23,200	26
23,201 - 24,000	27
24,001 - 24,900	28
24,901 - 25,000	29
25,001 - 28,000	30
28,001 - 33,000	35
33,001 - 37,000	40
37,001 - 41,000	45
41,001 - 46,000	50
46,001 - 50,000	55
50,001 - 54,000	60
54,001 - 59,000	65
59,001 - 64,000	70
64,001 - 70,000	75
70,001 - 76,000	80
76,001 - 83,000	85

Population Served	Minimum Number of Samples Per Month
83,001 - 90,000	90
90,001 - 96,000	95
96,001 - 111,000	100
111,001 - 130,000	110
130,001 - 160,000	120
160,001 - 190,000	130
190,001 - 220,000	140
220,001 - 250,000	150
250,001 - 290,000	160
290,001 - 320,000	170
320,001 - 360,000	180
360,001 - 410,000	190
410,001 - 450,000	200
450,001 - 500,000	210
500,001 - 550,000	220
550,001 - 600,000	230
600,001 - 660,000	240
660,001 - 720,000	250
720,001 - 780,000	260
780,001 - 840,000	270

Population Served	Minimum Number of Samples Per Month
840,001 - 910,000	280
910,001 - 970,000	290
970,001 - 1,050,000	300
1,050,001 - 1,140,000	310
1,140,001 - 1,230,000	320
1,230,001 - 1,320,000	330
1,320,001 - 1,420,000	340
1,420,001 - 1,520,000	350
1,520,001 - 1,630,000	360
1,630,001 - 1,730,000	370
1,730,001 - 1,850,000	380
1,850,001 - 1,970,000	390
1,970,001 - 2,060,000	400
2,060,001 - 2,270,000	410
2,270,001 - 2,510,000	420
2,510,001 - 2,750,000	430
2,750,001 - 3,020,000	440
3,020,001 - 3,320,000	450
3,320,001 - 3,620,000	460

Population Served	Minimum Number of Samples Per Month
3,620,001 - 3,960,000	470
3,960,001 - 4,310,000	480
4,310,001 - 4,690,000	490
$\overline{>}$ 4,690,001	500

Based on a history of no coliform bacterial contamination and on a sanitary survey by the State showing the water system to be supplied solely by a protected ground water source and free of sanitary defects, a community water system serving 25 to 1,000 persons, with written permission from the state, may reduce this sampling frequency except that in no case shall it be reduced to less than one per quarter.

(c) The supplier of water for a non-community water system shall sample for coliform bacteria in each calendar quarter during which the system provides water to the public. Such sampling shall begin within two years after the effective date of this part. If the State, on the basis of a sanitary survey, determines that some other frequency is more appropriate, that frequency shall be the frequency required under these regulations. Such frequency shall be confirmed or changed on the basis of subsequent surveys.

(d)(1) When the coliform bacteria in a single sample exceed four per 100 milliliters (§ 141.14(a)), at least two consecutive daily check samples shall be collected and examined from the same sampling point.

Additional check samples shall be collected daily, or at a frequency established by the State, until the results obtained from at least two consecutive check samples show less than one coliform bacterium per 100 milliliters.

(2) When coliform bacteria occur in three or more 10 ml portions of a single sample (§ 141.14(b)(1)), at least two consecutive daily check samples shall be collected and examined from the same sampling point. Additional check samples shall be collected daily, or at a frequency established by the State, until the results obtained from at least two consecutive check samples show no positive tubes.

(3) When coliform bacteria occur in all five of the 100 ml portions of a single sample (§ 141.14(b)(2)), at least two daily check samples shall be collected and examined from the same sampling point. Additional check samples shall be collected daily, or at a frequency established by the State, until the results obtained from at least two consecutive check samples show no positive tubes.

(4) The location at which the check samples were taken pursuant to paragraphs (d)(1), (2) or (3) of this section shall not be eliminated from future sampling without approval of

the State. The results from all coliform bacterial analyses performed pursuant to this subpart, except those obtained from check samples and special purpose samples, shall be used to determine compliance with the maximum contaminant level for coliform bacteria as established in §141.14. Check samples shall not be included in calculating the total number of samples taken each month to determine compliance with § 141.21(b) or (c).

(e) When the presence of coliform bacteria in water taken from a particular sampling point has been confirmed by any check samples examined as directed in paragraphs (d)(1), (2) or (3) of this section, the supplier of water shall report to the State within 48 hours.

(f) When a maximum contaminant level set forth in paragraphs (a) (b) or (c) of § 141.14 is exceeded, the supplier of water shall report to the State and notify the public as prescribed in § 141.31 and § 141.32.

(g) Special purpose samples, such as those taken to determine whether disinfection practices following pipe placement, replacement, or repair have been sufficient, shall not be used to determine compliance with § 141.14 or § 141.21 (b) or (c).

(h) A supplier of water of a community water system or a non-community water system may, with the approval of the State and based upon a sanitary survey, substitute the use of chlorine residual monitoring for not more than 75 percent of the samples required to be taken by paragraph (b), provided that the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the frequency of at least four for each substituted microbiological sample. There shall be at least daily determinations of chlorine residual. When the supplier of water exercises the option provided in this paragraph (h), he shall maintain no less than 0.2 mg/l free chlorine throughout the public water distribution system. When a particular sampling point has been shown to have a free chlorine residual less than 0.2 mg/l, the water at that location shall be retested as soon as practicable and in any event within one hour. If the original analysis is confirmed, this fact shall be reported to the State within 48 hours. Also, if the analysis is confirmed, a sample for coliform bacterial analysis must be collected from that sampling point as soon as practicable and preferably within one hour, and the results of such analysis reported to the State within 48 hours after the results are known to the supplier of water. Analyses for residual chlorine shall be made in accordance with Standard Methods for the Examination of Water and Wastewater, 13th Ed., pp 129-132. Compliance with the maximum contaminant levels for coliform bacteria shall be determined on the monthly mean or quarterly mean basis specified in §141.14 including those samples taken as a result of failure to maintain the required chlorine residual level. The State may withdraw its approval of the use of chlorine residual substitution at any time.

Sec. 141.22 Turbidity sampling and analytical requirements.

(a) Samples shall be taken by suppliers of water for both community water systems and non-community water systems at a representative entry point (s) to the water distribution system at least once per day, for the purpose of making turbidity measurements to determine compliance with § 141.13. The measurement shall be made in accordance with the recommendations set forth in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 13th Edition, pp. 350-353 (Nephelometric Method).

(b) If the result of a turbidity analysis indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be confirmed by resampling as soon as practicable and preferably within one hour. If the repeat sample confirms that the maximum allowable limit has been exceeded, the supplier of water shall report to the State within 48 hours. The repeat sample shall be the sample used for the purpose of calculating the monthly average. If the monthly average of the daily samples exceeds the maximum allowable limit, or if the average of two samples taken on consecutive days exceeds 5 TU, the supplier of water shall report to the State and notify the public as directed in § 141.31 and § 141.32.

(c) Sampling for non-community water systems shall begin within two years after the effective date of this part.

(d) The requirements of this § 141.22 shall apply only to public water systems which use water obtained in whole or in part from surface sources.

Sec. 141.23 Inorganic chemical sampling and analytical requirements.

(a) Analyses for the purpose of determining compliance with §141.11 are required as follows:

(1) Analyses for all community water systems utilizing surface water sources shall be completed within one year following the effective date of this part. These analyses shall be repeated at yearly intervals.

(2) Analyses for all community water systems utilizing only ground water sources shall be completed within two years following the effective date of this subpart. These analyses shall be repeated at three-year intervals.

(3) For non-community water systems, whether supplied by surface or ground water sources, analyses for nitrate shall be completed within two years following the effective date of this part. These analyses shall be repeated at intervals determined by the State.

(b) If the result of an analysis made pursuant to paragraph (a) indicates that the level of any contaminant listed in § 141.11 exceeds the maximum contaminant level, the supplier of water shall report to the State within 7 days and initiate three additional analyses at the same sampling point within one month.

(c) When the average of four analyses made pursuant to paragraph (b), rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall notify the State pursuant to § 141.31 and give notice to the public pursuant to § 141.32. Monitoring after public notification shall be at a frequency designated by the State and shall continue until the maximum contaminant level has not been exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective.

(d) The provisions of paragraphs (b) and (c) of this section notwithstanding, compliance with the maximum contaminant level for nitrate shall be determined on the basis of the mean of two analyses. When a level exceeding the maximum contaminant level for nitrate is found, a second analysis shall be initiated within 24 hours, and if the mean of the two analyses exceeds the maximum contaminant level, the supplier of water shall report his findings to the State pursuant to § 141.31 and shall notify the public pursuant to § 141.32.

(e) For the initial analyses required by paragraph (a)(1), (2) or (3), data for surface waters acquired within one year prior to the effective date and data for ground waters acquired within 3 years prior to the effective date of this part may be substituted at the discretion of the State.

(f) Analyses conducted to determine compliance with § 141.11 shall be made in accordance with the following methods:

(1) Arsenic - Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, pp. 95-96, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(2) Barium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 97-98, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(3) Cadmium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp. 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 101-103, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(4) Chromium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition,

pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 105-106, Environmental Protection Agency, Office of Technology Transfer, Washington, D. C. 20460, 1974.

(5) Lead-Atomic Absorption Method, Standards Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 112-113, Environmental Protection Agency, Office of Technology Transfer, Washington, D. C. 20460, 1974.

(6) Mercury-Flameless Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, pp 118-126, Environmental Protection Agency, Office of Technology Transfer Washington, D. C. 20460, 1974.

(7) Nitrate - Brucine Colorimetric Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 461-464, or Cadmium Reduction Method, Methods for Chemical Analysis of Water and Wastes, pp 201-206, Environmental Protection Agency, Office of Technology Transfer, Washington, D. C. 20460, 1974.

(8) Selenium - Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, p. 145, Environmental Protection Agency, Office of Technology Transfer, Washington, D. C. 20460, 1974.

(9) Silver - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, p 146, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(10) Fluoride - Electrode Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 172-174, or Methods for Chemical Analysis of Water and Wastes, pp 65-67; Environmental Protection Agency, Office of Technology Transfer, Washington, D.C., 20460, 1974, or Colorimetric Method with Preliminary Distillation, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 171-172 and 174-176, or Methods for Chemical Analysis of Water and Wastes, pp 59-60, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

Sec. 141.24 Organic chemical sampling and analytical requirements.

(a) An analysis of substances for the purpose of determining compliance with §141.12 shall be made as follows:

(1) For all community water systems utilizing surface water sources, analyses shall be completed within one year following the effective date of this part. Samples analyzed shall be collected during the period of the year designated by the State as the period when contamination by pesticides is most likely to occur. These analyses shall be repeated at intervals specified by the State but in no event less frequently than at three year intervals.

(2) For community water systems utilizing only ground water sources, analyses shall be completed by those systems specified by the State.

(b) If the result of an analysis made pursuant to paragraph (a) indicates that the level of any contaminant listed in § 141.12 exceeds the maximum contaminant level, the supplier of water shall report to the State within 7 days and initiate three additional analyses within one month.

(c) When the average of four analyses made pursuant to paragraph (b), rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall report to the State pursuant to § 141.31 and give notice to the public pursuant to § 141.32. Monitoring after public notification shall be at a frequency designated by the State and shall continue until the maximum contaminant level has not been exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective.

(d) For the initial analysis required by paragraph (a)(1) and (2), data for surface water acquired within one year prior to the effective date of this part and data for ground waters acquired within three years prior to the effective date of this part may be substituted at the discretion of the State.

(e) Analyses made to determine compliance with § 141.12(a) shall be made in accordance with Method for Organochlorine Pesticides in Industrial Effluents, MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

(f) Analyses made to determine compliance with § 141.12(b) shall be conducted in accordance with Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents, MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

Sec. 141.27 Alternative analytical techniques

With the written permission of the State an alternative analytical technique may be employed. An alternative technique shall be acceptable only if it is substantially equivalent to the prescribed test in both precision and accuracy as it relates to the determination of compliance with any maximum contaminant level. The use of the alternative analytical technique shall not decrease the frequency of monitoring required by this subpart.

Sec. 141.28 Approved laboratories

For the purpose of determining compliance with § 141.21 through 141.27, samples may be considered only if they have been analyzed by a laboratory approved by the State, except that measurements for turbidity and free chlorine residual may be performed by any person acceptable to the State.

Sec. 141.29 Monitoring of consecutive public water systems

When a public water system supplies water to one or more other public water systems, the State may modify the monitoring requirements imposed by this subpart to the extent that the interconnection of the systems justifies treating them as a single system for monitoring purposes. Any modified monitoring shall be conducted pursuant to a schedule specified by the State and concurred in by the Administrator of the U. S. Environmental Protection Agency.

Subpart D - Reporting, Public Notification and Record Keeping

Sec. 141.31 Reporting requirements

(a) Except where a shorter reporting period is specified in this subpart, the supplier of water shall report to the State within 40 days following a test, measurement or analysis required to be made by this subpart, the results of that test, measurement or analysis.

(b) The supplier of water shall report to the State within 48 hours the failure to comply with any primary drinking water regulation (including failure to comply with monitoring requirements) set forth in this part.

(c) The supplier of water is not required to report analytical results to the State in cases where a State laboratory performs the analysis and reports the results to the State office which would normally receive such notification from the supplier.

Section 141.32 Public notification.

(a) If a community water system fails to comply with an applicable maximum contaminant level established in Subpart B, fails to comply with an applicable testing procedure established in Subpart C, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirements of any schedule prescribed pursuant to a variance or exemption, or fails to perform any monitoring required pursuant to Section 1445(a) of the Act, the supplier of water shall notify persons served by the system of the failure or grant by inclusion of a notice in the first set of water bills of the system issued after the failure or grant and in any event by written notice within three months. Such notice shall be repeated at least once every three months so long as the system's failure continues or the variance or exemption remains in effect. If the system issues water bills less frequently than quarterly, or does not issue water bills, the notice shall be made by or supplemented by another form of direct mail.

(b) If a community water system has failed to comply with an applicable maximum contaminant level, the supplier of water shall notify the public of such failure, in addition to the notification required by paragraph (a), as follows:

(1) By publication on not less than three consecutive days in a newspaper or newspapers of general circulation in the area served by the system. Such notice shall be completed within fourteen days after the supplier of water learns of the failure.

(2) By furnishing a copy of the notice to the radio and television stations serving the area served by the system. Such notice shall be furnished within seven days after the supplier of water learns of the failure.

(c) If the area served by a community water system is not served by a daily newspaper of general circulation, notification by newspaper required by paragraph (b) shall instead be given by publication on three consecutive weeks in a weekly newspaper of general circulation serving the area. If no weekly or daily newspaper of general circulation serves the area, notice shall be given by posting the notice in post offices within the area served by the system.

(d) If a non-community water system fails to comply with an applicable maximum contaminant level established in Subpart B, fails to comply with an applicable testing procedure established in Subpart C, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirement of any schedule prescribed pursuant to a variance or exemption or fails to perform any monitoring required pursuant to Section 1445(a) of the Act, the supplier of water shall give notice of such failure or grant to the persons served by the system. The form and manner of such notice shall be prescribed by the State, and shall insure that the public using the system is adequately informed of the failure or grant.

(e) Notices given pursuant to this section shall not use unduly technical language, unduly small print or other methods which would frustrate the purpose of the notice. In areas designated by the State, bilingual notices shall be given. Notices should inform the public, but not unduly alarm the public. Notices may include a fair explanation of the significance or seriousness for the public health of the subject of the notice, a fair explanation of steps taken by the system to correct any problem, and the results of any additional sampling, and may indicate preventive measures that should be taken by the public.

(f) Notice to the public required by this section may be given by the State on behalf of the supplier of water.

(g) In any instance in which notification by mail is required by paragraph (a) but notification by newspaper or to radio or television stations is not required by paragraph (b), the State may order the supplier of water to provide notification by newspaper and to radio and television stations when circumstances make more immediate or broader notice appropriate to protect the public health.

Sec. 141.33 Record maintenance

Any owner or operator of a public water system subject to the provisions of this part shall retain on its premises or at a convenient location near its premises the following records:

(a) Records of bacteriological analyses made pursuant to this part shall be kept for not less than 5 years. Records of chemical analyses made pursuant to this part shall be kept for not less than 10 years. Actual laboratory reports may be kept, or data may be transferred to tabular summaries, provided that the following information is included:

(1) The date, place, and time of sampling, and the name of the person who collected the sample;

(2) Identification of the sample as to whether it was a routine distribution system sample, check sample, raw or process water sample or other special purpose sample;

(3) Date of analysis;

(4) Laboratory and person responsible for performing analysis;

(5) The analytical technique/method used; and

(6) The results of the analysis.

(b) Records of action taken by the system to correct violations of primary drinking water regulations, shall be kept for a period not less than 3 years after the last action taken with respect to the particular violation involved.

(c) Copies of any written reports, summaries or communications relating to sanitary surveys of the system conducted by the system itself, by a private consultant, or by any local, State or Federal agency, shall be kept for a period not less than 10 years after completion of the sanitary survey involved.

(d) Records concerning a variance or exemption granted to the system shall be kept for a period ending not less than 5 years following the expiration of such variance or exemption.

APPENDIX B

DESCRIPTION OF PUBLIC NON-COMMUNITY SYSTEMS BY USE CATEGORY

This appendix describes a breakdown of public non-community supply systems based on use category. Very few states have compiled this information, and of those that have, it appears that the data are still grossly incomplete. New York State was able to provide their breakdown of known non-community public water supplies, which is found in Table B-1. This accounts for only 9,634, or approximately 27 percent, of the NSF estimated 36,000 systems for that state.

Noting that the numbers in the first three categories (food service establishments, schools, and state institutions) should be reasonably close to the actual numbers distributed, an extrapolation was made to estimate the percentage of systems which belong to the final four categories (industrial, commercial, condominiums, and miscellaneous). This was accomplished by weighting each unknown category according to its number of known supplies, and distributing the appropriate percentages among the 82.28 percent of the unknown category systems. The results are given in Table B-2 along with a nationwide breakdown based on these percentages.

It was difficult to determine the limits and the range of applicability of these categories due to the lack of data, and therefore these results should be used with caution.

However, the figure trends appear to be compatible with assumptions made for similar estimations by the EPA Water Supply Division in a study of drinking water systems on and along interstate highways (Table B-3).

A further breakdown of the miscellaneous category into Federally administered components is presented in Table B-4. These data are presented in publications by the administering agency responsible for the sub-category given.

There are a large number of travellers who use small non-community water systems, although it is again difficult to specify quantitative data on populations serviced by the systems from each category. The problem is further complicated by the fact that there are quite significant seasonal variations in the water demand from non-community supply systems, especially from recreational areas. The following assumptions can be made with some confidence:

1. Drinking water supplies serving food service establishments, schools, state institutions, apartments, and industry cater to at least 25 persons per day for 75 percent of the year;

2. Drinking water supplies serving recreational areas and facilities cater to at least 25 persons per day for 35 percent of the year in the northern United States and 90 percent of the year in the southern United States;

3. Service to commercial business establishments is difficult to generalize due to size and type of business, and must be investigated on a categorical and regional basis.

Average annual system utilization for Federally administered facilities are presented in Table B-5. No other concrete results could be generated.

Accurate cost analysis cannot yet be made of treatment methods for these facilities, since there is a significant lack of data in many categories. It has become quite evident that little, if any, national effort has been placed in this area. Little useful information has been obtained from the few studies that have been completed by the joint ventures of the National Sanitation Foundation and the Conference of State Sanitary Engineers, by the EPA. Future emphasis in this area will have to proceed at the state-by-state inventory. In this report, all non-community systems are assumed to serve an average of 25 people a day for all 12 months of the year.

APR 0 3 REC'D

TABLE B-1

STATE OF NEW YORK
DEPARTMENT OF HEALTH
DIVISION OF SANITARY ENGINEERING
ESP - TOWER BUILDING
FOURTH FLOOR - ROOM 438
ALBANY, N.Y. 12237

Robert P. Whalen, M.D.
COMMISSIONER

MEREDITH H. THOMPSON, D. ENG.
ASSISTANT COMMISSIONER

BUREAU OF RESIDENTIAL
& RECREATION SANITATION

IRVING GROSSMAN, P.E.
DIRECTOR

April 1, 1975

Mr. Berry Gahron
185 Alewisebrook Parkway
Cambridge, Massachusetts 02138

Dear Mr. Gahron:

Doctor Thompson has asked me to supply you with information regarding non-municipal public water supplies in New York State.

The table below shows the number of known supplies by region and category at this time.

	REGIONS						
	Albany	Buffalo	Rochester	Syracuse	White Plains	TOTAL	
Food Service Establishments	1,145	202	422	955	2,994	5,718	6,380
Schools	146	14	22	103	230	515	
State Institutions	35	3	40	12	57	147	
Industrial	33	18	89	41	71	252	3,254
Commercial	459	20	300	175	167	1,121	
Condominiums & Apt. Complexes	62	2	2	5	104	175	
Miscellaneous	24	129	336	472	745	1,706	
Regional Totals	1,904	388	1211 ~~750~~	1,763 ~~1,766~~	4,368		

Statewide Total = 9,634 ~~9,176~~

The numbers in the first three categories should be reasonably close to the actual numbers of these establishments. This cannot be said of the remaining categories. At this time, no estimate can be given of the total numbers of these establishments. The reported numbers are simply the known supplies.

The commercial category includes commercial business establishments such as service stations, stores, shopping centers and grocers.

Examples of some establishments included in the miscellaneous category are resorts, bathing beaches, trailer parks, camps, springs and town and county buildings.

If you have any questions on these figures or require additional information, please feel free to contact this office.

Very truly yours,

Dennis J. Corrigan

Dennis J. Corrigan
Sanitary Engineer
Residential Sanitation Section

TABLE B-2

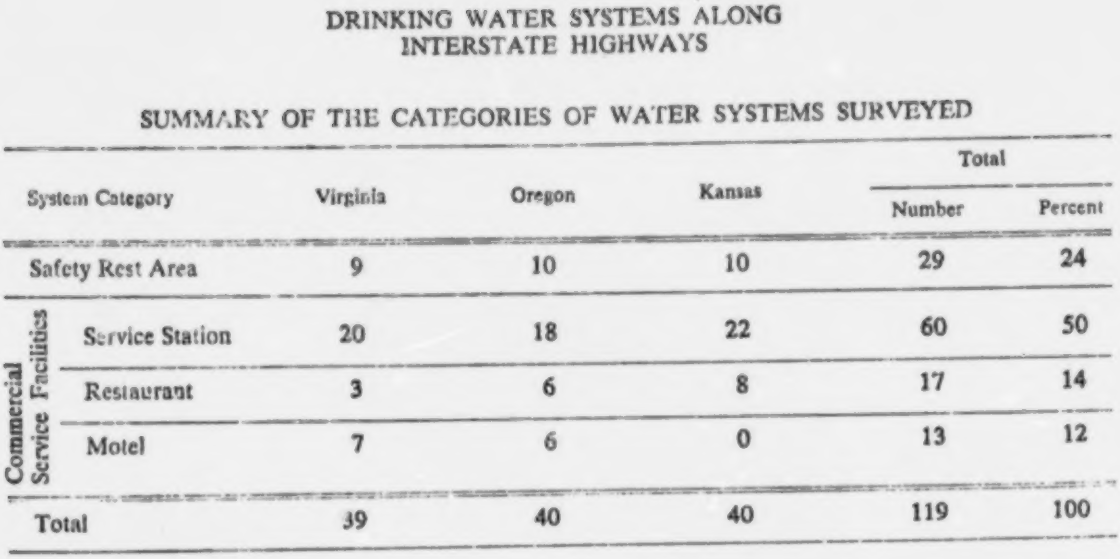
CATEGORY PERCENTAGE BREAKDOWN BASED ON NEW YORK STATE DATA AVAILABLE

CATEGORY	PERCENTAGE SYSTEMS IN CATEGORY (%)	ESTIMATED NUMBER OF SYSTEMS IN UNITED STATES[2]
1. Food Service Establishments	15.88	36,582
2. Schools	1.43	3,294
3. State Institution	0.41	945
4. Industrial[1]	6.37	14,674
5. Commercial[3]	28.31	65,217
6. Condominiums and Apartments	4.46	10,274
7. Miscellaneous[4]	43.14	99,381
TOTAL	100.00	230,367

Assumptions:

1. Categories 4 through 7 based on weighted data (see text).
2. Nationwide breakdown based on NSF estimates and New York data.
3. Commercial category includes commercial business establishments such as service stations, stores, shopping centers and grocers.
4. Micellaneous category includes resorts, beaches, parks, camps, springs, and town and country buildings.

TABLE B-3



DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

SUMMARY OF THE CATEGORIES OF WATER SYSTEMS SURVEYED

System Category		Virginia	Oregon	Kansas	Total	
					Number	Percent
Safety Rest Area		9	10	10	29	24
Commercial Service Facilities	Service Station	20	18	22	60	50
	Restaurant	3	6	8	17	14
	Motel	7	6	0	13	12
Total		39	40	40	119	100

Source: U.S. Environmental Protection Agency, Drinking Water Sources On and Along the National System of Interstate and Defense Highways, A Pilot Study, Water Supply Division, August 1971, p. 13.

TABLE B-4

FEDERALLY ADMINISTERED NON-COMMUNITY WATER SUPPLY SYSTEMS[a]

SUBCATEGORY	NUMBER OF SYSTEMS	POPULATION SERVED ANNUALLY
1. U.S. Forest Service	10,000	71×10^6
2. Interstate Highways	9,115	$1,250 \times 10^6$
3. U.S. Bureau of Reclamation	260	55×10^6
4. U.S. National Park Service	425	216×10^6

[a] Federally administered supplies account for about 20 percent of the miscellaneous category in Table B-2.

TABLE B-5

AVERAGE ANNUAL FEDERAL WATER SUPPLY UTILIZATION (NOT SEASONALLY ADJUSTED)

SUBCATEGORY	USE (PEOPLE/SYSTEM/DAY)
1. U.S. Forest Service	19
2. Interstate Highways	137
3. U.S. Bureau of Reclamation	580
4. U.S. National Park Service	1,390

APPENDIX C

QUESTIONNAIRE TO STATE AGENCIES WITH RESPONSIBILITY FOR DRINKING WATER REGULATIONS

Name and Address of Agency:

____

____

____

____

____

Person(s) Filling Out Questionnaire

____

____

1. LABORATORY CERTIFICATION

   a. Does the state have a program for certification of analytical laboratories which monitor the inorganic quality of drinking water?

      1) Local water system in-house labs? YES____ NO____
      2) Private commercial labs? YES____ NO____
      3) Municipal labs not operated by water depts? YES____ NO____
      4) State labs? YES____ NO____

      How many certified labs are there in each category?

      In-house_______ Private_______ Municipal_______ State_______

      Could you please attach a list of such laboratories?

   b. Does the state have a program for certification of analytical laboratories to monitor the organic and pesticide quality of drinking water?

      1) Local water system in-house labs? YES____ NO____
      2) Private commercial labs? YES____ NO____
      3) Municipal labs not operated by water depts? YES____ NO____
      4) State labs? YES____ NO____

How many certified labs are there in each category?

In-House_______ Private_______ Municipal_______ State_______

Could you please attach a list of such laboratories?

c. Does the state have a program for certification of analytical laboratories to monitor the bacteriological quality of drinking water?

1) Local water system in-house labs? YES____ NO____

2) Private commercial labs? YES____ NO____

3) Municipal labs not operated by water depts? YES____ NO____

4) State labs? YES____ NO____

How many certified labs are there in each category?

In-House_______ Private_______ Municipal_______ State_______

Could you please attach a list of such laboratories?

d. Does the state certify individual water system to monitor turbidity (yes/no) and residual chlorine (yes/no)? How many?

Turbidity________ Residual Chlorine________

2. MONITORING

a. Who performs water quality analyses?
(Answer with percents of total task work.)

TYPE OF LABORATORY

	In-House	Private Commercial	Municipal	State	TOTAL
Sample Collection					100
Inorganic Analyses					100
Organic Analyses					100
Pesticide Analyses					100
Coliform Analyses					100
Plate Count Analyses					100
Turbidity Analyses					100
Residual Chlorine					100
Radiological Analyses					100

b. Must performing labs be certified? YES____ NO____

c. Please supply data on the numbers of different types of drinking water systems within the state:

1) Number of systems drawing on surface water sources[a] and serving communitites[b] ___________.

2) Number of systems drawing only on ground water sources[c] and serving communities[b] ___________.

3) Number of systems drawing on surface water sources[a] and serving only transients[d] ___________.

4) Number of systems drawing only on ground water sources[c] and serving only transients__________.

5) Number of systems drawing only on suppliers of finished water___________.

d. Does the state have standards for the frequency of monitoring for: (If no requirement, answer "No")

	Community Systems		Transient Systems
	Surface Water	Ground Water	
Inorganics	Every_____Years	Every_____Years	Every_____Years
Organics	Every_____Years	Every_____Years	Every_____Years
Pesticides	Every_____Years	Every_____Years	Every_____Years
Coliform	________Samples per mo.	________Samples per mo.	________Samples per mo.
Plate Count	________ "	________ "	________ "
Turbidity	________ "	________ "	________ "

---

[a] May be supplemented by ground and finished waters.

[b] 25 or more permanent residents.

[c] May be supplemented by finished waters.

[d] Average of 25 or more in any three month period.

e. Please supply data on the work load of state laboratories performing water quality analyses:

Contaminant	How Many Samples Are Presently Analyzed Each Year?	How Many Samples Could Be Analyzed with Present Facilities and Manpower?
Inorganics		
Organics		
Pesticides		
Coliform		
Plate Count		
Turbidity		
Radiological		

f. Who pays for monitoring costs? (Answer with percentage of total costs)

1) Local Water Systems? ______

2) Municipal Agency? ______

3) State Agency? ______

g. If state laboratory does drinking water quality analyses, can you supply us with cost data for these analyses? (Annual Basis)

1) Direct Labor ____________

2) Supplies and Equipment ____________

3) Overhead ____________

4) Total Cost ____________

5) Number of Personnel (full time equivalent) ____________

3. ENFORCEMENT

a. Does the state enforce any standards for maximum contaminant levels in drinking water? YES____ NO____

b. If YES, do these standards conform to the 1962 PHS Drinking Water Standards? YES____ NO____

c. If enforced standards are substantially different from the 1962 PHS Standards, please describe the state standards:

____

____

____

____

d. How many inspectors does the state employ in its enforcement programs? ____________

e. What actions, if any, are taken against systems which violate standards? ____________________

____

____

f. Please name the state agencies, if any, responsible for:

1) Enforcement of standards ____________________

____

2) Recorder of violations ____________________

____

4. SAFE DRINKING WATER ACT

The latest draft of the Proposed Interim Primary Standards calls for the following frequencies of monitoring

	TYPE OF SYSTEM			
	Community		Transient	
Inorganics, Organics and Pesticides	Annually	Every 3 Years	Every 6 Years	Every 6 Years
Turbidity	Daily	Monthly	Daily	None
Coliform	2 to 500 Samples Per Month Based on Number of Customers Served*			
Plate Count	1 to 500 Samples Per Month Based on Number of Customers Served			

*1962 PHS, Recommended Sampling Frequencies.

a. Do you anticipate any difficulties with this level of monitoring in terms of the availability of analytical facilities? (If so, please describe) ____________________

b. Do you anticipate any diffficulties in funding this level of monitoring? (If so, please describe) ____________________

5. Does the state issue permits for construction of water supply systems? YES____ NO____

6. Does the state issue permits for construction of additional facilities at existing water supply systems? YES____ NO____

7. Does your state plan to encourage the use of residual chlorine monitoring to replace and/or supplement coliform density measurements? YES____ NO____

8. Please add any additional comments.

TABLE C-1

PERCENT OF INORGANIC ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	20	40	20	20
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	20	20	0	60
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	60	0	0	40
IDAHO	0	0	0	100
ILLINOIS				
INDIANA	75	0	1	24
IOWA	N	N	N	99
KANSAS	0	0	0	100
KENTUCKY	10	0	0	90
LOUISIANA				
MAINE	10	N	N	90
MARYLAND				
MASSACHUSETTS				
MICHIGAN	0	0	0	100
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	0	0	0	100
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	10	0	90
NEW YORK	N	N	N	N
NORTH CAROLINA	10	0	0	90
NORTH DAKOTA	10	0	1	90
OHIO	10	0	0	90
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	50	1	0	50
SOUTH DAKOTA				
TENNESSEE				
TEXAS	1	2	0	97
UTAH	0	30	0	70
VERMONT	0	0	0	100
VIRGINIA	0	0	0	100
WASHINGTON	0	100	0	90
WEST VIRGINIA	0	0	0	90
WISCONSIN				
WYOMING	0	0	0	100

N is not known.
No entry indicates lack of response.

TABLE C-2

STATE LAB WORK LOAD (INORGANICS)

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	few hundred	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	1,666	1,666
COLORADO	550	550
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	9,000	9,000
HAWAII	669	1,000
IDAHO	214	250
ILLINOIS		
INDIANA	16,620	17,000
IOWA	700-900	N
KANSAS	300	1,500
KENTUCKY	546 (partial) 8 (total)	600 (partial) 10 (total)
LOUISIANA		
MAINE	500	+25%+
MARYLAND		
MASSACHUSETTS		
MICHIGAN	13 (plus 144 mercury only)	13
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	300	1,500
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	N	N
NEW MEXICO	7,000	7,700
NEW YORK	N	N
NORTH CAROLINA	4,000	4,000
NORTH DAKOTA	3,000	+20%
OHIO	1,646	2,000
OKLAHOMA		
OREGON		
PENNSYLVANIA	2,609	N
RHODE ISLAND	592	N
SOUTH CAROLINA	2,200	2,500
SOUTH DAKOTA	5,500	6,500
TENNESSEE		
TEXAS	3,325	3,500
UTAH	2,000	3,000
VERMONT	4,000	4,000
VIRGINIA	728	N
WASHINGTON	2,500	2,500
WEST VIRGINIA	1,000	1,000
WISCONSIN		
WYOMING	60	220

N is not known.
No entry indicates lack of response.

TABLE C-3

PERCENT OF ORGANIC ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	5	90	0	5
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	10	10	0	80
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	100	0	0	0
IDAHO	N	N	N	N
ILLINOIS				
INDIANA	1	N	0	99
IOWA	N	0	0	99
KANSAS	100	0	0	0
KENTUCKY	0	0	0	100
LOUISIANA				
MAINE	N	N	N	N
MARYLAND				
MASSACHUSETTS				
MICHIGAN	0	0	0	100
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	100	0	0	0
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	N	N	N	N
NEW YORK	N	N		
NORTH CAROLINA	10	0	0	90
NORTH DAKOTA	95	0	0	100
OHIO	0	0	0	0
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	0	0	0	100
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	0	0	0	0
UTAH	0	0	0	100
VERMONT	0	0	0	0
VIRGINIA	0	0	0	100
WASHINGTON				
WEST VIRGINIA	0	0	0	90
WISCONSIN				
WYOMING	0	100	0	0

N is not known.
No entry indicates lack of response.

TABLE C-4

STATE LAB WORK LOAD (ORGANICS)

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	Few	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	1,666	1,666
COLORADO	550	550
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	0
HAWAII	0	0
IDAHO	214	250
ILLINOIS		
INDIANA	38	40
IOWA	700-900	N
KANSAS	0	0
KENTUCKY	75	N
LOUISIANA	N	N
MAINE		
MARYLAND		
MASSACHUSETTS		
MICHIGAN	13	13
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	0
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	N	N
NEW MEXICO	0	0
NEW YORK	N	N
NORTH CAROLINA	100	100
NORTH DAKOTA	N	N
OHIO	0	0
OKLAHOMA		
OREGON		
PENNSYLVANIA	N	N
RHODE ISLAND	N	N
SOUTH CAROLINA	175	175
SOUTH DAKOTA	N	N
TENNESSEE		
TEXAS	0	0
UTAH	N	N
VERMONT	0	0
VIRGINIA	30	N
WASHINGTON	0	0
WEST VIRGINIA	10	20
WISCONSIN		
WYOMING	0	0

N is not known.
No entry indicates lack of response.

TABLE C-5

PERCENT OF PESTICIDE ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	0	50	N	50
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	5	5	0	90
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORI[illegible]	N	N	N	N
GEORG[illegible]A	0	0	0	0
HAWAI[illegible]	90	0	0	100
IDAHO	0	0	0	100
ILLINOIS				
INDIANA	0	0	0	100
IOWA	N	N	N	99
KANSAS	100	0	0	0
KENTUCKY	0	0	0	100
LOUISIANA	N	N	N	N
MAINE				
MARYLAND				
MASSACHUSETTS				
MICHIGAN	0	0	0	100
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	100	0	0	0
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	0	0	100
NEW YORK	N	N		
NORTH CAROLINA	10	0	0	90
NORTH DAKOTA	0	N	0	100
OHIO	0	0	0	100
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	0	0	0	100
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	1	0	0	99
UTAH	0	0	0	100
VERMONT	0	0	0	0
VIRGINIA	0	0	0	100
WASHINGTON	0	0	0	100
WEST VIRGINIA	0	0	0	20
WISCONSIN				
WYOMING	0	100	0	0

N is not known.
No entry indicates lack of response.

TABLE C-6

STATE LAB WORK LOAD PESTICIDES

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		N
ALASKA	0	N
ARIZONA	N	1,666
ARKANSAS	1,666	0
CALIFORNIA	0	N
COLORADO	N	
CONNECTICUT		
DELAWARE		
DISTRICT OF COLUMBIA		N
FLORIDA	N	0
GEORGIA	0	16
HAWAII	16	200
IDAHO	167	
ILLINOIS		10
INDIANA	0	N
IOWA	700-900	0
KANSAS	0	200
KENTUCKY	20	
LOUISIANA		N
MAINE	N	
MARYLAND		
MASSACHUSETTS		13
MICHIGAN	13	
MINNESOTA		
MISSISSIPPI		
MISSOURI		N
MONTANA	N	0
NEBRASKA	0	
NEVADA		
NEW HAMPSHIRE		N
NEW JERSEY	N	300
NEW MEXICO	200	N
NEW YORK	N	under 50
NORTH CAROLINA	under 50	0
NORTH DAKOTA	0	300
OHIO	300	
OKLAHOMA		
OREGON		N
PENNSYLVANIA	N	N
RHODE ISLAND	184	175
SOUTH CAROLINA	175	N
SOUTH DAKOTA	N	
TENNESSEE		100
TEXAS	100	20
UTAH	20	0
VERMONT	0	N
VIRGINIA	30	N
WASHINGTON	N	20
WEST VIRGINIA	20	
WISCONSIN		0
WYOMING	0	

N is not known.
No entry indicates lack of response.

TABLE C-7

PERCENT OF COLIFORM ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	0	10	N	90
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	30	1	1	49
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	10	90
HAWAII	60	0	0	40
IDAHO	0	2	0	98
ILLINOIS				
INDIANA	15	0	5	80
IOWA	0	5	45	50
KANSAS	20	0	10	70
KENTUCKY	20	0	10	70
LOUISIANA				
MAINE	10	0	0	90
MARYLAND				
MASSACHUSETTS	N	N	N	N
MICHIGAN	82	0	0	18
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	20	0	10	70
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	0	0	100
NEW YORK	N	N		
NORTH CAROLINA	25	0	0	75
NORTH DAKOTA	10	0	1	90
OHIO	10	0	0	90
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	68	1	N	32
SOUTH DAKOTA	0	0	10	90
TENNESSEE				
TEXAS	10	0	0	90
UTAH	25	2	13	60
VERMONT	0	0	0	100
VIRGINIA	25	0	0	80
WASHINGTON	10	0	50	40
WEST VIRGINIA	0	5	25	70
WISCONSIN				
WYOMING	1	0	0	99

N is not known.

No entry indicates lack of response.

TABLE C-8

STATE LAB WORK LOAD COLIFORM

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	20,000	N
ARIZONA	N	N
ARKANSAS	15,000	15,000
CALIFORNIA	9,800	9,800
COLORADO	N	N
CONNECTICUT		
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	40,000	40,000
HAWAII	5,953	6,000
IDAHO	7,191	10,000
ILLINOIS		
INDIANA	25,648	26,000
IOWA	40,000	N
KANSAS	N	N
KENTUCKY	21,000	21,000
LOUISIANA		
MAINE	10,000	12,500
MARYLAND		
MASSACHUSETTS	N	N
MICHIGAN	24,000	24,000
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	0
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	N	N
NEW MEXICO	25,000	25,000
NEW YORK	N	N
NORTH CAROLINA	40,000	40,000
NORTH DAKOTA	7,000	N
OHIO	45,000	45,000
OKLAHOMA		
OREGON		
PENNSYLVANIA	2,609	N
RHODE ISLAND	6,870	N
SOUTH CAROLINA	50,000	70,000
SOUTH DAKOTA	15,000	17,000
TENNESSEE		
TEXAS	260,322	275,000
UTAH	20,000	40,000
VERMONT	20,000	20,000
VIRGINIA	84,520	N
WASHINGTON	15,000	15,000
WEST VIRGINIA	N	N
WISCONSIN		
WYOMING	7,575	10,000

N is not known.
No entry indicates lack of response.

TABLE C-9

PERCENT OF PLATE COUNT ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	0	10	0	90
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	N	N	N	N
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	60	0	0	40
IDAHO	1			
ILLINOIS				
INDIANA	5	0	0	95
IOWA	0	0	10	90
KANSAS	20	0	10	70
KENTUCKY	100	0	0	0
LOUISIANA				
MAINE	0	0	0	100
MARYLAND				
MASSACHUSETTS	N	N	N	N
MICHIGAN	100	0	0	0
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	20	0	10	70
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	0	0	100
NEW YORK	N	N	N	N
NORTH CAROLINA	N	N	N	N
NORTH DAKOTA	10	0	1	90
OHIO	0	0	0	0
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	5	N	N	95
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	0	0	0	100
UTAH	30	0	10	60
VERMONT	0	0	0	0
VIRGINIA	85	0	0	15
WASHINGTON				
WEST VIRGINIA	0	0	0	100
WISCONSIN				
WYOMING	0	100	0	0

N is not known.
No entry indicates lack of response.

TABLE C-10

STATE LAB WORK LOAD PLATE COUNT

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	several hundred	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	15,000	15,000
COLORADO	0	0
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	0
HAWAII	1,000	1,000
IDAHO	0	N
ILLINOIS		
INDIANA	0	0
IOWA	0	0
KANSAS	16,000	16,000
KENTUCKY	0	0
LOUISIANA		
MAINE	400	25%
MARYLAND		
MASSACHUSETTS	N	N
MICHIGAN	few	few
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	16,000	16,000
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	N	N
NEW MEXICO	45	2,500
NEW YORK	N	N
NORTH CAROLINA	0	N
NORTH DAKOTA	0	
OHIO	10	N
OKLAHOMA		
OREGON		
PENNSYLVANIA	N	N
RHODE ISLAND	1,480	N
SOUTH CAROLINA	3,000	5,000
SOUTH DAKOTA	N	N
TENNESSEE		
TEXAS	50	300
UTAH	2,600	3,000
VERMONT	not routinely analyzed	
VIRGINIA	42	N
WASHINGTON	0	0
WEST VIRGINIA	N	N
WISCONSIN		
WYOMING	0	0

N is not known.
No entry indicates lack of response.

TABLE C-11

PERCENT OF TURBIDITY ANALYIS DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	30	50	10	10
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	90	0	N	9
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	60	0	0	40
IDAHO				
ILLINOIS				
INDIANA	95	0	1	4
IOWA	0	0	20	80
KANSAS	100	0	0	0
KENTUCKY	50	0	0	50
LOUISIANA				
MAINE	20	0	0	80
MARYLAND				
MASSACHUSETTS	N	N	N	N
MICHIGAN	99	0	0	1
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	100	0	0	0
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	0	95	5
NEW YORK	100	0	0	0
NORTH CAROLINA	10	0	0	90
NORTH DAKOTA	1	0	1	95
OHIO	5	0	0	95
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	92	0	0	8
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	100	0	0	0
UTAH	0	0	50	50
VERMONT	0	0	0	100
VIRGINIA	100	0	0	0
WASHINGTON	50	0	0	50
WEST VIRGINIA	0	0	0	60
WISCONSIN				
WYOMING	95	0	0	5

N is not known.
No entry indicates lack of response.

TABLE C-12

STATE LAB WORK LOAD TURBIDITY

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	few	N
ARIZONA	N	N
ARKANSAS		
CALIFORNIA	N	N
COLORADO	500	500
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	0
HAWAII	250	500
IDAHO	N	N
ILLINOIS		
INDIANA	388	500
IOWA	700-900	N
KANSAS	0	1,500
KENTUCKY	546	600
LOUISIANA		
MAINE	400	+25%+
MARYLAND		
MASSACHUSETTS	N	N
MICHIGAN	450	450
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	1,500
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	Unknown N	Unknown N
NEW MEXICO	6,000	6,600
NEW YORK	N	N
NORTH CAROLINA	4,000	4,000
NORTH DAKOTA	0	N
OHIO	1,646	2,000
OKLAHOMA		
OREGON		
PENNSYLVANIA	N	N
RHODE ISLAND	1,120	N
SOUTH CAROLINA	2,200	3,000
SOUTH DAKOTA	N	N
TENNESSEE		
TEXAS	0	100
UTAH	2,000	3,000
VERMONT	4,000	4,000
VIRGINIA	728	N
WASHINGTON	W/Inorganics figure	W/Inorganics figure
WEST VIRGINIA	500	500
WISCONSIN		
WYOMING	0	0

N is not known.
No entry indicates lack of response.

TABLE C-13

PERCENT OF RADIOLOGICAL ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	0	100	0	0
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	0	2	0	98
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	0	0	0	0
IDAHO				
ILLINOIS				
INDIANA	0	0	0	100
IOWA	0	0	1	99
KANSAS	100	0	0	0
KENTUCKY	0	0	0	100
LOUISIANA				
MAINE	0	0	0	0
MARYLAND				
MASSACHUSETTS	N	N	N	N
MICHIGAN	0	0	0	100
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	100	0	0	0
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	100	0	0
NEW YORK	0	0	0	100
NORTH CAROLINA	0	0	0	100
NORTH DAKOTA	0	0	0	100
OHIO	0	0	0	100
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	0	0	0	100
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	0	0	0	100
UTAH	0	0	0	100
VERMONT	0	0	0	0
VIRGINIA	0	0	0	100
WASHINGTON	0	0	0	100
WEST VIRGINIA	C	0	0	100
WISCONSIN				
WYOMING	0	0	0	0

N is not known.
No entry indicates lack of response.

TABLE C-14

STATE LAB WORK LOAD RADIOLOGICAL

	NUMBER OF SAMPLES PRESENTLY ANALYZED	POTENTIAL NUMBER OF SAMPLES ANALYZED
ALABAMA		
ALASKA	0	N
ARIZONA	N	0
ARKANSAS		
CALIFORNIA	1,000	1,000
COLORADO	670	670
CONNECTICUT	N	N
DELAWARE		
DISTRICT OF COLUMBIA		
FLORIDA	N	N
GEORGIA	0	0
HAWAII	0	0
IDAHO	N	N
ILLINOIS		
INDIANA	0	10
IOWA	700-900	N
KANSAS	0	0
KENTUCKY	4	8
LOUISIANA		
MAINE	N	N
MARYLAND		
MASSACHUSETTS	N	N
MICHIGAN	120	120
MINNESOTA		
MISSISSIPPI		
MISSOURI		
MONTANA	N	N
NEBRASKA	0	0
NEVADA		
NEW HAMPSHIRE		
NEW JERSEY	N	N
NEW MEXICO	0	0
NEW YORK	N	N
NORTH CAROLINA	900	900
NORTH DAKOTA		
OHIO	1,690	2,500
OKLAHOMA		
OREGON		
PENNSYLVANIA	N	N
RHODE ISLAND	54	N
SOUTH CAROLINA	800	N
SOUTH DAKOTA	N	N
TENNESSEE		
TEXAS	200	250
UTAH	128	7,900
VERMONT	0	0
VIRGINIA	30	N
WASHINGTON	0	0
WEST VIRGINIA	N	N
WISCONSIN		
WYOMING	0	0

N is not known.
No entry indicates lack of response.

TABLE C-15

PERCENT OF RESIDUAL CHLORINE ANALYSES DONE BY FOUR AGENCIES BY STATE

	IN-HOUSE	PRIVATE COMMERCIAL	MUNICIPAL	STATE
ALABAMA				
ALASKA	30	10	50	10
ARIZONA	0	0	0	100
ARKANSAS				
CALIFORNIA	N	N	N	N
COLORADO	99	0	0	1
CONNECTICUT	N	N	N	N
DELAWARE				
DISTRICT OF COLUMBIA				
FLORIDA	N	N	N	N
GEORGIA	0	0	0	0
HAWAII	60	0	0	40
IDAHO	0	0	100	0
ILLINOIS				
INDIANA	100	0	0	0
IOWA	80	0	80	20
KANSAS	95	0	0	5
KENTUCKY	75	0	25	0
LOUISIANA				
MAINE	100	0	0	0
MARYLAND				
MASSACHUSETTS	N	N	N	N
MICHIGAN	100	0	0	0
MINNESOTA				
MISSISSIPPI				
MISSOURI				
MONTANA	N	N	N	N
NEBRASKA	95	0	0	5
NEVADA				
NEW HAMPSHIRE				
NEW JERSEY	N	N	N	N
NEW MEXICO	0	0	95	5
NEW YORK	100	0	0	0
NORTH CAROLINA	N	N	N	N
NORTH DAKOTA	100	0	0	0
OHIO	100	0	0	0
OKLAHOMA				
OREGON				
PENNSYLVANIA	N	N	N	N
RHODE ISLAND	N	N	N	N
SOUTH CAROLINA	65	0	0	35
SOUTH DAKOTA	N	N	N	N
TENNESSEE				
TEXAS	100	0	0	0
UTAH	0	0	100	0
VERMONT	0	25	75	0
VIRGINIA	100	0	0	0
WASHINGTON	95	0	5	0
WEST VIRGINIA	0	0	90	10
WISCONSIN				
WYOMING	0	0	90	10

N is not known.
No entry indicates lack of response.

TABLE C-16

NUMBER OF SYSTEMS BY TYPE AND SOURCE

	COMMUNITY SYSTEMS		NON-COMMUNITY SYSTEMS		
	SURFACE	GROUND	SURFACE	GROUND	FINISHED
ALABAMA					
ALASKA	N	N	N	N	N
ARIZONA	12	1,900	N	N	N
ARKANSAS					
CALIFORNIA	300	800	N	N	N
COLORADO	179	345	N	95%	100
CONNECTICUT	N	N	N	N	N
DELAWARE					
DISTRICT OF COLUMBIA					
FLORIDA	N	N	N	N	N
GEORGIA	130	2,500	0	100	200
HAWAII	50+	75+	N	N	0
IDAHO	125	820	175	878	12
ILLINOIS					
INDIANA	50	393	N	10,000	20
IOWA	54	768	N	N	N
KANSAS	2	450	0	N	8
KENTUCKY	N	N	N	N	119
LOUISIANA					
MAINE	66	104	N	N	N
MARYLAND					
MASSACHUSETTS	N	N	N	N	N
MICHIGAN	96	1,878	10	16,000	242
MINNESOTA					
MISSISSIPPI					
MISSOURI					
MONTANA	N	N	N	N	N
NEBRASKA	2	450	0	N	8
NEVADA					
NEW HAMPSHIRE					
NEW JERSEY	46	N	N	N	N
NEW MEXICO	17	353	N	N	N
NEW YORK	400	735	N	N	400
NORTH CAROLINA	169	2,470	N	N	68
NORTH DAKOTA	33	224	N	N	N
OHIO	167	1,485	100	19,000	113
OKLAHOMA					
OREGON					
PENNSYLVANIA	500	3,875	0	11,800	N
RHODE ISLAND	10	31	N	N	N
SOUTH CAROLINA	70	1,000	25	1,353	200
SOUTH DAKOTA	20	350	5	600	1
TENNESSEE					
TEXAS	400	6,000	150	10,000	500
UTAH	25	600	5	500	40
VERMONT	133	238	100	3,000	N
VIRGINIA	137	1,166	0	9,400	50
WASHINGTON	100	1,400	50	2,000	100
WEST VIRGINIA	170	360	N	200	120
WISCONSIN					
WYOMING	46	372	16	410	6

N is not known.

No entry indicates lack of response.

APPENDIX D

CONTAMINANT REMOVAL BY CONVENTIONAL WATER TREATMENT PROCESSES

D.1 Removal of Turbidity

There are a number of conventional water treatments which are employed, either singly or in combination, for the removal of turbidity from water intended for human consumption. Turbidity is imparted to water by suspended solid particles whose sizes are so small as to constitute a nonsettleable colloidal suspension.

High turbidity levels render water unacceptable for human consumption both for aesthetic and health reasons. The origins of turbidity particulates are partly mineral (including possibly toxic heavy metals), partly organic, and partly microbiological (including possible disease causing microorganisms). Moreover, high turbidity interferes with disinfection and other treatment practices.

Although filtration by itself sometimes suffices to reduce turbidity to acceptable levels, chemical treatments are commonly practiced to induce coagulation and flocculation. The resulting coalescence into larger particles allows partial settling and increases filtration efficiency.

The chemicals most commonly used for coagulation and flocculation are aluminum sulfate [$Al_2(SO_4)_3$], or alum, and iron (III) sulfate [$Fe_2(SO_4)_3$], or ferric alum. Both alum and ferric alum are water soluble, but at medium to high values of pH, they react with water to form solid hydroxides in the form of gelatinous precipitates which incorporate the turbidity particles into easily filtered or settleable masses.

In principle, these "flocs" of aluminum and ferric hydroxides have a potential to absorb dissolved solids including toxic heavy metals and other inorganics which fall under the primary standards. Control of Ba^{++} by precipitation as the insoluble sulfate salt is also possible from considerations of chemical equilibrium. Studies have been performed on the following species to determine removal efficiencies through coagulation, flocculation, and filtration: organic mercury

(CH_3HgCl)[1,2] , inorganic mercury ($HgCl_2$)[1,2], Barium (Ba^{++})[2], inorganic selenium (IV)[2], inorganic selenium (VI)[2], inorganic arsenic (III)[2,3], inorganic arsenic (V)[2,3], and total chromium.[4] The results are shown in Table D-1.

In the studies by Logsdon and Symons, the removal efficiencies of mercury tended to parallel initial levels of turbidity[1]. The failure of sulfate ion to remove barium was attributed to supersaturation[2]; the importance of oxidation states was noted for selenium and arsenic[2]. It was observed that selenium is primarily a ground water problem and that the reduced state [Se(IV)] should therefore predominate[2]. (Fortunately Se(IV) is the easier of the two to remove.) Laboratory[2,3] and field studies both showed that chlorination improves the removal efficiency for arsenic, presumably thorugh oxidation of As(III) to As(V).

D.2 Chlorination

Chlorination is very widely practiced as a means of disinfecting public water supplies, and its use in the United States has reduced the once epidemic incidence of water-borne disease to almost negligible proportions.

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[1] G.S. Logsdon and J.M. Symons, "Mercury Removal by Conventional Water Treatment Techniques," J. Am. Water Works Assn., 65, 554 (1958).

[2] G.S. Logsdon and J.M. Symons, "Removal of Heavy Metals by Conventional Treatment," in J.E. Sabadel, editor, "Traces of Heavy Metals in Water Removal Processes and Monitoring," United States Environmental Protection Agency Report #902/9-74-001, Region II, 1973, pp. 225-56.

[3] Y.S. Shen, "Study of Arsenic Removal from Drinking Water," J. Am. Water Works Assn., 65, 543 (1973).

[4] G.M. Zemansky, "Removal of Trace Metals During Conventional Water Treatment," J. Am. Water Works Assn., 66, 606 (1974).

TABLE D-1

REMOVAL OF HEAVY METALS BY COAGULATION, FLOCCULATION AND FILTRATION

SPECIES	APPROXIMATE PERCENT REMOVAL		TYPE OF STUDY	REFERENCE[d]
	ALUM	FERRIC ALUM		
Organic Mercury	<30	<30	Jar Test	1,2
Inorganic Mercury	<30	30-60	Jar Test	1,2
Barium	<30	<30	Jar Test	2
Inorganic Selenium (IV)	<30	60-80	Jar Test	2
Inorganic Selenium (VI)	<30	<30	Jar Test	2
Inorganic Arsenic (III)	<30	50-80	Jar Test	2
Inorganic Arsenic (V)	60-90	90-100	Jar Test	2
Total Arsenic[a]	50-80		Jar Test	3
Total Arsenic[b]	100		Jar Test, Field Survey	3
Total Chromium[c]	0-60		Field Survey	4

[a] Ferric chloride coagulation.

[b] Chlorination followed by ferric chloride coagulation.

[c] Coagulants not specified.

[d] See footnotes, preceding page.

When Cl_2 dissolves in water at a neutral pH, it disproportionates:

$$Cl_2 + H_2O \rightarrow H^+ + Cl^- + HClO \qquad (1)$$

forming hydrochloric acid and hypochlorous acid (HClO). All the disinfecting and oxidizing power of "aqueous chlorine" resides in the hypochlorous acid. The pH is of course lowered.

Several of the inorganic chemicals listed in the primary standards are affected by chlorination. Trivalent arsenic (As(III)) is oxidized to the pentavalent state (As(V)). Tetravalent selenium (Se(IV)) does not oxidize rapidly in the presence of HClO, but standard oxidation potentials predict that it should be converted to Se(VI). Nitrite (NO_2^-) is oxidized to nitrate (NO_3^-). Free cyanide (CN^-) is destroyed, but some cyanide complexes are resistant to chlorination. Chlorination can potentially destroy some organometallic compounds. (The reaction of HClO with methyl mercury should therefore be investigated.)

Aqueous chlorine reacts readily with ammonia. The resulting chloramines retain much of the disinfecting power of chlorine and represent much longer-lasting chlorine residuals (combined chlorine residual), but are much weaker oxidizing agents. Thus, when ammonia is present in the water (either naturally or by deliberate addition), under these conditions, the reactions as cited in the previous paragraph are not as likely to take place.

Aqueous chlorine also reacts with organics to produce chlorinated organics, such as those found in the New Orleans water supply last year and implicated in the high incidence of bladder cancer in that city. One possible benefit of this reaction, however, is that the chlorinated organics are probably more completely adsorbed on activated carbon than are their precursors.

D.3 Activated Carbon Filtration

Filtration through activated carbon is a well known, effective treatment for water with high levels of odor and color. This is due to carbon's extraordinary capacity to adsorb organic molecules onto its surface. It is likely that activated carbon filtration would constitute adequate treatment for water with excessive levels of total organics (as measured by carbon chloroform extraction) and of pesticides.

Logsdon and Symons have investigated the removal of several trace metal species with activated carbon.[1] Effective removals of both organic and inorganic mercury were observed with removal efficiencies of up to 100 percent using granular activated carbon in columns. They found that activated carbon was ineffective against barium, selenium and arsenic. Smith,[2] however, has reported that when carbon is prepared with a high content of oxygenated surface groupings, it functions as an ion exchange medium and is therefore a good adsorber of ionic species. Carbon's other removal mechanisms include true adsorption, precipitation, oxidation or reduction to insoluble forms, and mechanical filtration. Smith's literature survey disclosed effective removals of Cr, Pb, Ni, Cd, Zn, Fe, Mn, Ca, Al, Bi, Cu, Ge, as well as the aforementioned work on Hg. Suitable carbons can be prepared by heating carbon in the presence of oxygen or by slurrying it with nitric acid.

It should be noted that activated carbon has a 100 percent removal efficiency for chlorine.

D.4 Lime Softening

In lime softening, calcium hydroxide ($Ca(OH)_2$) is used as a base to convert the natural bicarbonate (HCO_3^-) content of water to carbonate ($CO_3^=$). The pH of course rises. As a result, the insoluble compounds $CaCO_3$, $MgCO_3$ and (in the case of excess lime softening) $Mg(OH)_2$ form and fall out of solution as precipitates.

Lime softening has many variations, depending both on the composition of the feed water and on the desired quality of the finished water. In addition to lime, a particular lime softening process may also use CO_2, Na_2CO_3, or NaOH. Ordinary lime softening raises pH to the range of 8-10; in excess lime softening the pH goes over 10 but is later reduced - for example, by aeration with CO_2 (a weak acid).

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[1] Logsdon and Symons, "Mercury Removal by Conventional Water Treatment Techniques," 1958.

[2] S.B. Smith, "Trace Metals Removal by Activated Carbon," in J.E. Sabade, pp. 55-70.

Lime softening can cause some heavy trace metals to precipitate as hydroxides or carbonates; it can also convert species such as $HAsO_2$, $H_2AsO_4^-$, and $HAsO_4^=$, which are soluble in the presence of Ca^{++} to AsO_2^- and $AsO_4^{\equiv}$, whose calcium salts precipitate.

Hem and Durum[1] have studied the equilibrium solubility of lead as a function of carbonate and pH, and concluded that a pH of 8 is sufficient to reduce the dissolved lead content to a level which is less than 10 percent of the maximum value permitted by the primary standards. Lime softened water should therefore satisfy the lead standard, and moreover should be incapable of dissolving lead pipes and lead joints in water distribution systems.

Logsdon and Symons[2] have studied the effectiveness of lime softening on mercury (both organic and inorganic), barium, arsenic (III), arsenic (V), selenium (IV) and selenium (VI). Their results are summarized in Table D-2. The arsenic results parallel those for ferric alum coagulation. They found that chlorination of As(III) followed by lime softening achieved removal efficiencies characteristic of As(V).

TABLE D-2

REMOVAL OF TRACE HEAVY METALS WITH LIME

SPECIES	APPROXIMATE PERCENT REMOVAL pH 8.5-9.5	pH 10.5-11.5
Organic Mercury	0	0
Inorganic Mercury	20-40	60-80
Barium	60-90	80-95
Inorganic Selenium (IV)	∿20	20-50
Inorganic Selenium (VI)	<10	<10
Inorganic Arsenic (III)	10-20	60-80
Inorganic Arsenic (V)	30-50	90-100

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[1] J.D. Hem and W.H. Durum, "Solubility and Occurrence of Leak in Surface Water," J. Am. Water Works Assn., 65, 562 (1973).

[2] Logsdon and Symons, "Mercury Removal by Conventional Water Treatment Techniques," 1958.

APPENDIX E

DATA BASE AND COST ESTIMATES OF WATER TREATMENT

This appendix presents the development of cost functions for water treatment processes used in this study. The origins of the data base utilized are also included. This description should provide the necessary background to the cost estimates for water treatment to meet the Interim Primary Drinking Water Regulations.

The description is divided into two main sections. Section E.1 illustrates the cost functions and estimates for larger water supply systems (systems that supply more than 1,000 m^3/day [264,000 gpd]). Section E.2 describes the corresponding costs for small systems. The need for such a distinction stems from the fact that cost functions for large supply systems are not valid for systems of smaller capacity. Consequently, different sets of functions were devised for the processes being considered, which include the following: (1) clarification (consisting of direct filtration), (2) chlorination, (3) activated carbon, (4) ion exchange, (5) pH control, and (6) activated alumina.

Prior to the presentation of these cost functions, the associated assumptions are stated below:

1. To estimate the quantity of water production, the average daily production shown in Table 4-2 was used for each population category;
2. Electricity costs 3 cents per kilowatt-hour;
3. Land costs $202 per hectare;
4. Capital costs generally included expenses for equipment purchase, installation, construction, design engineering study, land, site development, and construction overhead. Operating and maintenance costs (O&M) include labor, supplies, materials, chemicals, electric utility, and general maintenance;
5. The interest rate is 7 percent.

E.1 Large System Costs

The cost functions for large water supply systems were generated primarily from the results of a report by D. Volkert & Associates.[1] These functions, which have been compared favorably with another report,[2] are summarized in Table E-1. The first column lists the treatment processes. The second column lists the cost estimates, and the third column indicates the appropriate comments for that process. It should be noted that the cost estimates are for individual processes; cascading them in series may lead to lower costs. Moreover, these functions are only valid for plants with capacities between 1,000 m^3/day (264,000 gpd) and 300,000 m^3/day (78 mgd). For the cost functions, the following keywords are used:

C = Construction cost

OM = Annual O&M costs, excluding labor

A = Area of land in hectares

SD = Site developemnt cost

L = Annual labor cost

OML = Annual O&M costs, including labor

Q = Plant capacity in m^3/day

Unless specified, these cost estimates are in terms of 1972 dollars. They have to be adjusted to 1975 dollars using the discount factor.

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[1] David Volkert & Associates, Monograph of the Effectiveness and Cost of Water Treatment Processes for the Removal of Specific Contaminants, Vol. I, Technical Manual (Bethesda, Maryland: David Volkert & Associates, 1972).

[2] I.C. Watson, Study of the Feasibility of Desalting Municipal Water Supplies in Montana. Manual for Calculation of Conventional Water Treatment Costs, Supplement to Final Report (Arlington, Virginia: Resources Studies Group, 1972).

TABLE E-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
COAGULATION & SEDIMENTATION	$C = 45000(Q/1000)^{0.796}$ $SD = 40000(Q/1000)^{0.66}$ $L = 6400(Q/1000)$ $OM = 2700(Q/1000)$ $A = 0.074(Q/1000)$	1. Flash water 2. Usually followed by filtration
FILTRATION	$C = 64000(Q/1000)^{0.676}$ $SD = 11000(Q/1000)^{0.761}$ $L = 11000(Q/1000)^{0.948}$ $CM = 14149\ (Q/1000)^{0.948}$ $A = 0.026(Q/1000)$	1. Rapid sand filter for a rate of 10 m^3/m^2/day
CHLORINATION	Equipment cost = $3700(Q/1000)^{0.533}$ Enclosure structure cost = $800(Q/1000)$ Cost of chlorine per year = (\$0.55/kg) x 365 Q x (dosage in mg/l) x 4.01 x $10^{-3}/0.7$	1. Use solution feed 2. Assume 4 mg/l dosage

TABLE E-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS (CONT.)

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
ACTIVATED CARBON	C for adsorption $= 23000(Q/1000)^{0.849}$ C for carbon regeneration $= 12000(Q/1000)^{0.656}$ $OML = 21000(Q/1000)^{0.146}$ OM supplies $= 9000(Q/1000)^{0.169}$ Annual fuel cost $= 300(Q/1000)^{0.606}$ Granular carbon replacement cost per year $= 300(Q/1000)$	1. Granular carbon used. 2. Three month replacement.
ACTIVATED ALUMINA	$C = 22000(Q/1000)^{0.631}$ $OML = 3200(Q/1000)^{0.785}$ Chemical cost for each mg/l of fluoride removed per year $= 2300(Q/1000)$	

TABLE E-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS (CONT.)

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
ION EXCHANGE	$C = 0.22 \times 10^6 (Q/100)^{0.703}$ $SD = 52000(Q/1000)^{0.666}$ $OML = 16000(Q/1000)^{0.47}$ OM Supplies = 0.01C Resin replacement cost = 0.03C Annual power cost $= 0.03 \times 360 \times 365 \times (Q/1000)^{0.87}$ $A = 0.03(Q/1000)$ Annual chemical cost $= 5 \times 10^{-5} \times 365Q$ x (ppm reduction)	1. Assume 1000 ppm reduction in TDS
pH Control	Cost of lime = 2¢/kg Cost of soda ash = 8.5¢/kg Amount of lime used per year in kg $= (1.42 \times CO_2 + 0.623 (T + M)) \times (Q/1000)$ Amount of soda ash in kg/year $+ 1.081(M + CNH) \times (Q/1000)$ Equipment cost $= 3700(Q/1000)^{0.533}$ Enclosure cost = 800(Q/1000)	1. CO_2 is concentration of CO_2 in mg/1 as $CaCO_3$. (Assumed 84 mg/1) Similarly, T is total alkalinity, (328 mg/1) M the required magnesium reduction, (120 mg/1) and CNH calcium non-carbonate hardness. (10 mg/1)

E.2 Small System Costs

In this study, a small system is considered to be one producing less than 264,000 gallons (1,000 m^3) per day. Assuming a water requirement of 100 to 150 gallons per capita per day, the flow rate range of interest is from about 2,500 gallons per day ($\approx$ 10 m^3/day) to about 300,000 gpd ($\approx$1,100 m^3/day).

Cost information for small systems was obtained through (1) personal conversation with several water treatment equipment manufacturers and suppliers, and (2) a study of conventional water supply costs conducted by Control Systems Research, Inc. for the Office of Saline Water, U.S. Department of the Interior.[1]

The approach used in requesting cost information from vendors was as follows. First, each manufacturer or supplier was queried as to the exact nature of his business. This allowed obtained cost data to be qualified in terms of actual type of equipment and services supplied for a stated price. The various business functions of the vendors contacted included suppliers of $40 cartridge filter products for home use, manufacturers of treatment unit "packages" for commercial/industrial use, suppliers of complete clarification systems for small municipal systems and/or industrial use, and suppliers of treatment systems designed to handle site-specific problems. Confidence in survey results was gained by considering responses only in terms of the vendor categories from which the responses came.

Secondly, each vendor was asked to provide general cost information (capital, installation, O&M) for equipment customarily used in water treatment applications within the flow rate range of interest. It was acknowledged that facilities and equipment provided in a given application is determined from several factors including; (1) raw water quality, (2) desired product water quality, (3) flow rate, (4) existing facilities, (5) system and equipment flexibility, (6) operation and maintenance needs of equipment, and other site-specific characteristics.

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[1] I.C. Watson, Resources Studies Group, CSR, Inc., Manual for Calculation of Conventional Water Treatment Costs (Washington, D.C.: Office of Saline Water, U.S. Department of the Interior, March 1972).

Since site-specific factors are not easily quantified on a general basis, vendors were asked for a general indication of costs. Responses were therefore based on either general equipment catalogue costs or actual vendor experience in providing facilities for small systems.

Information received from vendors was supplemented with cost data contained in the aforementioned CSR[1] study, which was based largely on equipment cost information provided by vendors. The CSR report was prepared with an emphasis on developing cost curves for systems used in municipal application and was designed to provide a means for estimating the costs of conventional treatment systems on the basis of individual unit operations. Cost functions derived from CSR data reflect 1972 prices and are thus multiplied by the appropriate factor in order to present results in 1975 dollars. A 7 percent interest rate was assumed.

Cost estimating functions for small systems are presented below in tabular form with appropriate comments regarding the equipment and services represented by each function. A list of vendors contacted is then presented. The following nomenclature is used:

C = Capital equipment cost

I = Equipment installation costs

O&M = Equipment operation and maintenance costs, annual

GPD = Gallons per day

Q = Plant capacity in cubic meters per day

GPM = Gallons per minute

SE = Site and enclosure costs

IMC = Initial media costs

It should be pointed out here that the cost curves for small and large systems will not produce a continuous function. The main reason for this is that each set of curves was developed independently and perhaps under differing assumptions.

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[1] Control Systems Research Inc. is now known as KAPPA Systems Inc., Arlington, Virginia.

The cost differences that occur at the small and large system breakpoint do not materially affect the overall cost estimates. In any event, it was not within the scope of this project to develop a single continuous function for all system sizes covered by the Act.

However, because of the tremendous range in system size, from 25 persons to over 1,000,000, there are several reasons why it may be difficult to develop a continuous function for all systems:

1. Small systems can employ package plants;
2. Small systems generally do not require full-time maintenance;
3. Small system treatment package plants may not require housing facilities.

TABLE E-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
CHLORINATION	$C = (0.386)^{Q}/(10)^{2,283}$ $O\&M = 0.751^{Q}/(10)^{0.768}$	1. For small systems, solution feed hypochlorinators are the most feasible kind of disinfection equipment. 2. O&M includes power and chemical costs and normal care of hypochlorinator unit. 3. Assumes 4 ppm Cl.
CLARIFICATION (COAGULATION, SEDIMENTATION, FILTRATION)	$C \text{ and } I = 1.5 \times 10^{5} \; {\frac{GPD}{10^{3}}}^{0.196}$ $= 4.47 \times 10^{5}\left(\frac{Q}{10^{3}}\right)^{0.196}$ $O\&M = 0.06 \; [C \text{ and } I]$	1. C and I cost reflects completely automatic filtration plant for use in treating surface waters to potability standards. Equipment provided includes chemical feed, coagulation, floculation, sedimentation, filtration, and also building with foundation and sanitary services. 2. Costs reflect a municipal small system situation where bids on a clarification system would be received. 3. Added pumping, piping, drainage not provided. 4. C and I and O&M estimates (Maintenance supplies, labor, chemicals and power costs) compare favorably with CSR data.

TABLE E-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
FILTRATION	$C = (0.277)^{Q}/(10)^{3.917}$ $O \& M = (0.101)^{Q}/(10)^{3.140}$	1. Costs are for filtration system used for source of water between 0-100 JTU. 2. C and I includes filter media and vessel, pumping equipment, piping, and controls for filter system, and erected housing. O&M includes pump power, chemical costs, maintenance and labor.
ION EXCHANGE	$C \text{ and } I = 2 X 10^{4} \frac{GPD}{10^{3}} 0.37$ $= 2.546 X 10^{3} \frac{Q}{10^{3}} 0.37$ $O \& M - 0.07 [C \text{ and } I]$	1. Costs for unit package designed for industrial applications. 2. C and I includes demineralizer units with automatic controls, plastic piping, rinse alarm. 3. Pumping equipment, pretreatment equipment, chemical storage tanks not included. 4. O & M involves pumping care and power, chemical tanks and chemicals, manual tank filling.

TABLE E-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
pH CONTROL	Cost of lime = 2¢/kg Cost of soda ash = 8.5¢/kg Amount of lime used per year in kg = (1.42 x CO_2 + 0.623 (T + M)) x Q/1000) Amount of soda ash in kg/year = 1.081(M + CNH) x (Q/1000) $C = (0.386)^{Q}/(10)^{2.283}$	1. CO_2 is concentration of CO_2 in mg/l as $CaCO_3$. Similarly, T is total alkalinity, M the required magnesium reduction, and CNH calcium noncarbonate hardness.

TABLE E-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

TREATMENT PROCESS	COST ESTIMATES	COMMENTS
ACTIVATED CARBON	$C \text{ and } I = 73.5 \text{ X } 10^3 [\text{MGD}]\ 0.845$ $= 24.4 \text{ X } 10^3 \left(\frac{Q}{10^3}\right)^{0.845}$ $SE = 2.29 \text{ X } 10^3 \left[\frac{Q}{10^3}\right]^{0.571}$ $O\&M = [1.8 \text{ X } 10^3 (\text{MGD})^{0.37}] 1.07$ $= 11.73 \text{ X } 10^3 \left(\frac{Q}{10^3}\right)^{0.37}$	1. Costs for use of carbon for taste and odor control with light organic load. 2. Carbon replacement cost assumed to be 7% of annual O&M. 3. C and I are for rubber lined pressure filter vessels, piping, valves etc., but not pumping equipment. 4. O&M includes general maintenance, supplies, power, and carbon replacement.
ACTIVATED ALUMINA	$C \text{ and } I = 54 \text{ X } 10^3 [\text{MGD}]^{0.62}$ $= 19.3 \text{ X } 10^3 \left(\frac{Q}{10^3}\right)^{0.62} +$ $29{,}401 \left(\frac{Q}{10^3}\right) \quad 0.98$ $O \& M = 3.8 \text{ X } 10^3 \left(\frac{Q}{10^3}\right) \quad 0.79$	1. C and I includes all equipment for defluoridation system including tanks piping, valves, pumping, and housing. 2. O&M includes chemical costs, annual alumina charge, general repairs, media replacement.

TABLE E-3

SMALL SYSTEM EQUIPMENT MANUFACTURERS CONTACTED

MANUFACTURER	LOCATION
Baker Filtration Co.	Huntington Beach, CA
Baroid Division, N.L. Industries	Houston, TX
Culligan Company	Northbrook, IL
Ecodyne-Craver Water Division	Lenexa, KY
Envirotech, Inc.	Belmont, MA
General Filter Company	Ames, IA
Hayward Filter Company	Santa Anna, CA
Hungerford & Terry, Inc.	Clayton, NJ
Lea Manufacturing	Waterbury, CT
Neptune Microfloc	Corvallis, OR
N.Y. Mixing Equipment Co.	Wakefield, MA
North American Carbon, Inc.	Columbus, OH
Roberts Filter Manufacturing Co.	Darby, PA
Wallace & Turnan, Div. of Pennwalt	Belleville, NJ
Wastewater Systems, Inc.	Chicago, IL
Water Control Equipment Co.	Houston, TX
Westcore Associates	Salt Lake City, UT

APPENDIX F

TREATMENT COSTS FOR INDIVIDUAL CONTAMINANTS BY POPULATION SERVED AND SOURCE OF WATER

TABLE F-1

CAPITAL AND O&M COSTS[a] OF CHLORINATION AND CLARIFICATION UNIT PROCESSES BY POPULATION SIZE CATEGORY

	CHLORINATION				CLARIFICATION			
			PROCESS COSTS ($/Thousand)				PROCESS COSTS ($/Thousand)	
POPULATION SIZE CATEGORY	NUMBER OF PLANTS	POPULATION AFFECTED	CAPITAL	O & M	NUMBER OF PLANTS	POPULATION AFFECTED	CAPITAL	O & M
25-99	1,526	95,674	1,052	106	252	13,436	5,292	476
100-499	2,410	646,081	2,892	457	653	174,669	19,590	1,436
500-999	607	460,477	1,092	267	293	205,200	12,013	732
1,000-2,499	466	765,073	1,220	414	376	581,421	19,656	1,020
2,500-4,999	211	770,559	1,562	443	215	735,165	32,250	7,310
5,000-9,999	133	972,849	1,596	611	111	746,412	29,970	7,992
10,000-99,999	170	4,545,996	5,100	2,720	195	4,759,166	124,600	46,600
100,000-999,999	12	2,663,860	2,520	2,160	27	6,675,097	91,600	64,600
>1,000,000	0	0	0	0	2	5,010,761	44,000	50,000
TOTAL	5,557	11,140,771	17,054	7,178	2,126	19,103,371	379,371	188,568

[a] Clarification includes direct filtration only.

TABLE F-2

BREAKDOWN OF TREATMENT[a] COSTS FOR MERCURY (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	SURFACE WATER $		GROUND WATER $		POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
	CAPITAL	O & M	CAPITAL	O & M		
25-99	287,000	20,300	5,535,000	391,500	8,372	142
100-499	1,428,000	100,800	18,632,000	1,315,200	73,253	295
500-999	1,300,000	93,600	9,100,000	655,200	71,784	104
1,000-2,499	2,660,000	188,100	10,920,000	772,200	145,027	97
2,500-4,999	6,580,000	658,000	15,980,000	1,598,000	161,340	48
5,000-9,999	8,910,000	847,000	18,630,000	1,771,000	224,121	34
10,000-99,999	34,000,000	2,890,000	54,000,000	4,590,000	990,328	44
100,000-999,999	33,000,000	2,820,000	22,000,000	1,880,000	846,174	5
>1,000,000	0	0	0	0	0	0
TOTAL	88,165,000	7,617,800	154,797,000	12,973,100	2,520,399	769

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[a] The number of plants affected was calculated by multiplying the 2.11 percent ground water and 2.20 percent surface water of mercury MCL exceeders in the EPA Interstate Carrier Study by the total number of groundwater and surface water systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-3

BREAKDOWN OF TREATMENT[a] COSTS FOR CHROMIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER $		POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
	CAPITAL	O & M		
25-99	1,107,000	78,300	1,601	27
100-499	3,740,000	264,000	13,472	55
500-999	1,800,000	129,600	12,602	18
1,000-2,499	2,240,000	158,400	23,081	16
2,500-4,999	3,290,000	329,000	22,728	7
5,000-9,999	4,050,000	385,000	30,724	5
10,000-99,999	12,000,000	1,020,000	115,075	6
100,000-999,999	0	0	0	0
>1,000,000	0	0	0	0
TOTAL	28,227,000	2,364,300	219,283	134

[a] The number of plants affected by calculated by multiplying the 0.42 percent of chromium MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-4

BREAKDOWN OF TREATMENT[a] COSTS FOR BARIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER $		POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
	CAPITAL	O & M		
25-99	369,000	26,100	533	9
100-499	1,292,000	91,200	4,490	19
500-999	600,000	43,200	4,200	6
1,000-2,499	840,000	59,400	7,693	6
2,500-4,999	1,410,000	141,000	7,576	3
5,000-9,999	1,620,000	154,000	10,241	2
10,000-99,999	4,000,000	340,000	38,358	2
100,000-999,999	0	0	0	0
>1,000,000	0	0	0	0
TOTAL	10,131,000	854,900	73,091	47

[a] The number of plants affected was calculated by multiplying the 0.14 percent of barium MCL exceeders in the CWSS Study by the total number of groundwater systems in each category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-5

BREAKDOWN OF TREATMENT[a] COSTS FOR LEAD (PH CONTROL) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	SURFACE WATER CAPITAL $	SURFACE WATER O & M	GROUND WATER CAPITAL $	GROUND WATER O & M	POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
25-99	1,380	6	92,460	428	8,073	136
100-400	6,000	60	326,400	3,264	68,451	277
500-999	5,400	114	162,000	3,420	64,670	93
1,000-2,499	10,000	360	195,000	7,020	121,088	82
2,500-4,999	22,500	660	255,000	7,480	122,861	37
5,000-9,999	36,000	1,440	276,000	11,040	167,258	26
10,000-99,999	120,000	6,800	810,000	45,900	655,945	31
100,000-999,999	0	0	420,000	38,000	342,278	2
>1,000,000	0	0	0	0	0	0
TOTAL	201,280	9,440	2,536,860	116,552	1,550,624	684

[a] The number of plants affected was calculated by multiplying the 0.43 percent surface water and 2.10 percent ground water of lead MCL exceeders in the CWSS Study by the total number of surface and groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-6

BREAKDOWN OF TREATMENT[a] COSTS FOR ARSENIC (ACTIVATED ALUMINA) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER $		POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
	CAPITAL	O & M		
25-99	70,200	5,940	1,601	27
100-499	335,500	34,650	13,472	55
500-999	216,000	27,000	12,602	18
1,000-2,499	352,000	48,000	23,081	16
2,500-4,999	259,000	77,000	22,728	7
5,000-9,999	300,000	105,000	30,724	5
10,000-99,999	780,000	402,000	115,075	6
100,000-999,999	0	0	0	0
>1,000,000	0	0	0	0
TOTAL	2,312,700	699,590	219,283	134

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[a] The number of plants affected was calculated by multiplying the 0.42 percent arsenic MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-7

BREAKDOWN OF TREATMENT[a] COSTS FOR NO_3 (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER $ CAPITAL	GROUND WATER $ O & M	POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
25-99	8,118,000	574,200	11,823	198
100-499	27,336,000	1,929,600	99,439	402
500-999	13,300,000	957,600	93,020	133
1,000-2,499	16,100,000	1,138,500	170,360	115
2,500-4,999	23,500,000	2,350,000	167,760	50
5,000-9,999	27,540,000	2,618,000	226,774	34
10,000-99,999	78,000,000	6,630,000	849,364	39
100,000-999,999	22,000,000	1,880,000	324,933	2
>1,000,000	0	0	0	0
TOTAL	215,894,000	18,077,900	1,943,473	973

[a] The number of plants affected was calculated by multiplying the 3.1 percent of NO_3 MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multipled by the cost of treating the mean-sized plant in each size category.

TABLE F-8

BREAKDOWN OF TREATMENT[a] COSTS FOR SELENIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	SURFACE WATER CAPITAL $	SURFACE WATER O & M	GROUND WATER CAPITAL $	GROUND WATER O & M	POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
25-99	82,000	5,800	2,952,000	208,800	4,375	74
100-499	340,000	24,000	9,996,000	705,600	37,362	152
500-999	300,000	21,600	4,900,000	352,800	35,602	52
1,000-2,499	560,000	39,600	5,880,000	415,800	67,914	46
2,500-4,999	1,410,000	141,000	8,930,000	893,000	70,583	22
5,000-9,999	2,430,000	231,000	10,530,000	1,001,000	96,617	16
10,000-99,999	8,000,000	680,000	30,000,000	2,550,000	392,050	19
100,000-999,999	0	0	0	0	0	0
>1,000,000	0	0	0	0	0	0
TOTAL	13,122,000	1,143,000	73,188,000	6,127,000	704,503	381

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[a] The number of plants affected was calculated by multiplying the 1.13 percent groundwater and 0.44 percent surface water of selenium MCL exceeders in the EPA Inventory by the total number of groundwater and surface water systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-9

BREAKDOWN OF TREATMENT[a] COSTS FOR CADMIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER CAPITAL $	O & M	POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
25-99	1,476,000	104,400	2,135	36
100-499	4,964,000	350,400	17,963	73
500-999	2,400,000	172,800	16,803	24
1,000-2,499	2,940,000	207,900	30,774	21
2,500-4,999	4,230,000	423,000	30,305	9
5,000-9,999	5,670,000	539,000	40,965	7
10,000-99,999	14,000,000	1,190,000	153,433	7
100,000-999,999	0	0	0	0
>1,000,000	0	0	0	0
TOTAL	35,680,000	2,987,500	292,378	177

[a] The number of plants affected was calculated by multiplying the 0.56 percent of cadmium MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE F-10

BREAKDOWN OF TREATMENT[a] COSTS FOR FLUORIDE (ACTIVATED ALUMINA) BY POPULATION SERVED AND SOURCE OF WATER

POPULATION SERVED	GROUND WATER CAPITAL $	GROUND WATER O & M	POPULATION AFFECTED	PROJECTED # OF VIOLATING PLANTS
25-99	829,400	70,180	19,069	319
100-499	3,952,800	408,240	160,386	648
500-999	2,568,000	321,000	150,032	214
1,000-2,499	4,070,000	555,000	274,775	185
2,500-4,999	2,997,000	891,000	270,581	81
5,000-9,999	3,240,000	1,134,000	365,765	54
10,000-99,999	8,190,000	4,221,000	1,369,942	63
100,000-999,999	2,480,000	2,480,000	524,086	4
>1,000,000	0	0	0	0
TOTAL	28,327,200	10,080,420	3,134,636	1,568

[a] The number of plants affected was calculated by multiplying the 5.0 percent of fluoride MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

APPENDIX G

TREATMENT, O&M, AND ANNUALIZED COSTS

TABLE G-1

TOTAL ANNUAL CAPITAL EXPENDITURES BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL CAPITAL EXPENDITURES PER PLANT (DOLLARS)[b]	TOTAL CAPITAL EXPENDITURES PER CAPITA (DOLLARS)[b]
CLARIFICATION	1,261	16,390,692	62.39	62.39	62.39	62.39	62.39	312.0	247,373	19.03
NO_3	577	1,667,500	35.51	35.51	35.51	35.51	35.51	177.5	307,595	106.47
CHLORINATION	3,296	9,558,762	7.01	7.01				14.0	4,255	1.47
MERCURY	456	2,162,502	39.96	39.96	39.96	39.96	39.96	199.8	437,969	92.39
SELENIUM	226	604,464	14.19	14.19	14.19	14.19	14.19	71.0	314,042	117.41
CADMIUM	105	250,860	5.67	5.67	5.67	5.87	5.67	29.3	279,449	116.96
LEAD	406	1,330,435	.45	.45	.45	.45	.45	2.3	5,549	1.69
FLUORIDE	930	2,689,518	4.66	4.66	4.66	4.66	4.66	23.3	25,044	8.66
CHROMIUM	79	186,145	4.64	4.64	4.64	4.64	4.64	23.2	292,019	123.37
BARIUM	28	62,712	1.67	1.67	1.67	1.67	1.67	8.3	296,817	132.64
ARSENIC	79	188,145	.38	.38	.38	.38	.38	1.9	23,926	10.11
TOTAL COMMUNITY CAPITAL COSTS[a]			176.73	176.73	169.72	169.72	169.72	862.6		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-2

TOTAL ANNUAL CAPITAL EXPENDITURES BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	865	2,712,679	13.48	13.48	13.48	13.48	13.48	67.4	77,942	24.85
NO_3	396	275,973	7.67	7.67	7.67	7.67	7.67	38.4	96,916	139.01
CHLORINATION	2,261	1,561,969	1.52	1.52				3.0	1,341	1.92
MERCURY	313	357,697	8.63	8.63	8.63	8.63	8.63	43.2	138,000	120.63
SELENIUM	155	100,039	3.07	3.07	3.07	3.07	3.07	15.3	98,947	153.31
CADMIUM	72	41,518	1.27	1.27	1.27	1.27	1.27	6.3	86,046	152.71
LEAD	278	220,189	.10	.10	.10	.10	.10	.5	1,749	2.21
FLUORIDE	638	445,118	1.01	1.01	1.01	1.01	1.01	5.0	7,891	11.31
CHROMIUM	55	31,138	1.00	1.00	1.00	1.00	1.00	5.0	92,009	161.06
BARIUM	19	10,379	.36	.36	.36	.36	.36	1.8	94,151	173.45
ARSENIC	55	31,138	.08	.08	.08	.08	.08	.4	7,538	13.20
TOTAL COMMUNITY CAPITAL COSTS[a]			38.19	38.19	36.67	36.67	36.67	186.4		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-3

TOTAL ANNUAL CAPITAL EXPENDITURES BY TREATMENT PROCESS
(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	2,126	19,103,371	75.87	75.87	75.87	75.87	75.87	379.4	178,444	19.86
NO_3	973	1,943,473	43.18	43.18	43.18	43.18	43.18	215.9	221,665	111.09
CHLORINATION	5,557	11,140,771	8.53	8.53				17.1	3,069	1.53
MERCURY	769	2,520,399	48.59	48.59	48.59	48.59	48.59	243.0	315,945	96.40
SELENIUM	381	704,503	17.26	17.26	17.26	17.26	17.26	86.3	226,535	122.51
CADMIUM	177	292,376	7.14	7.14	7.14	7.14	7.14	35.7	201,562	122.03
LEAD	684	1,550,624	.55	.55	.55	.55	.55	2.7	4,003	1.77
FLUORIDE	1,568	3,134,636	5.67	5.67	5.67	5.67	5.67	28.3	16,066	9.04
CHROMIUM	134	219,283	5.65	5.65	5.65	5.65	5.65	28.2	210,649	128.72
BARIUM	47	73,091	2.03	2.03	2.03	2.03	2.03	10.1	215,553	138.61
ARSENIC	134	219,283	.46	.46	.46	.46	.46	2.3	17,259	10.55
TOTAL COMMUNITY CAPITAL COSTS[a]			214.92	214.92	206.39	206.39	206.39	1049.0		

[a] Totals may not add due to rounding.

[b] Based on 1983 figures when treatment is fully implemented.

TABLE G-4

TOTAL ANNUAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	676	41,056	1.42	1.42	1.29	1.29	1.29	6.7	9,929	163.36
100-499	2,827	734,370	11.13	11.13	10.32	10.32	10.32	53.2	18,819	72.44
500-999	1,192	859,895	7.84	7.84	7.43	7.43	7.43	38.0	31,855	44.15
1,000-2,499	1,208	1,857,829	11.57	11.57	11.07	11.07	11.07	56.3	46,650	30.33
2,500-4,999	604	2,088,812	18.41	18.41	17.72	17.72	17.72	90.0	148,835	43.11
5,000-9,999	378	2,579,266	20.74	20.74	20.04	20.04	20.04	101.6	268,646	39.39
10,000-99,999	516	12,390,476	67.59	67.59	65.33	65.33	65.33	331.2	642,266	26.73
100,000-999,999	42	9,574,236	28.94	28.94	27.92	27.92	27.92	141.6	3,350,365	14.79
>1,000,000	2	5,010,761	8.80	8.80	8.80	8.80	8.80	44.0	22,000,000	8.78
TOTAL PUBLICLY-OWNED COMMUNITY CAPITAL COSTS[a]	7,444	35,134,744	176.45	176.45	169.90	169.90	169.90	862.6		

[a] Totals may not add due to rounding.

[b] Based on 1983 figures when treatment is fully implemented.

TABLE G-5

TOTAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,070	125,838	4.35	4.35	3.95	3.95	3.95	20.6	9,929	163.36
100-499	2,212	574,668	6.71	6.71	8.07	8.07	8.07	41.6	18,819	72.44
500-999	370	267,097	2.44	2.44	2.31	2.31	2.31	11.8	31,855	44.15
1,000-2,499	242	372,458	2.32	2.32	2.22	2.22	2.22	11.3	46,650	30.33
2,500-4,999	86	295,394	2.61	2.61	2.51	2.51	2.51	12.7	148,835	43.11
5,000-9,999	49	335,162	2.70	2.70	2.60	2.60	2.60	13.2	268,848	39.39
10,000-99,999	66	1,594,260	8.70	8.70	8.41	8.41	8.41	42.6	642,268	26.73
100,000-999,999	10	2,202,192	6.66	6.66	6.42	6.42	6.42	32.6	3,350,365	14.79
>1,000,000										
TOTAL INVESTOR-OWNED COMMUNITY CAPITAL COSTS[a]	5,106	5,767,068	36.47	36.47	36.49	36.49	36.49	186.4		

[a] Totals may not add due to rounding.

[b] Based on 1983 figures when treatment is fully implemented.

TABLE G-6

TOTAL ANNUAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM
(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL[a]	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,746	166,894	5.77	5.77	5.24	5.24	5.24	27.3	9,929	163.36
100-499	5,039	1,309,038	19.83	19.83	18.39	18.39	18.39	94.8	18,819	72.44
500-999	1,562	1,126,992	10.28	10.28	9.73	9.73	9.73	49.8	31,855	44.15
1,000-2,499	1,450	2,230,267	13.89	13.89	13.26	13.26	13.26	67.6	46,650	30.33
2,500-4,999	690	2,382,206	21.01	21.01	20.22	20.22	20.22	102.7	148,835	43.11
5,000-9,999	427	2,914,450	23.44	23.44	22.64	22.64	22.64	114.8	268,848	39.39
10,000-99,999	582	13,984,736	76.29	76.29	73.74	73.74	73.74	373.8	642,266	26.73
100,000-999,999	52	11,776,426	35.60	35.60	34.34	34.34	34.34	174.2	3,350,385	14.79
>1,000,000	2	5,010,781	8.80	8.80	8.80	8.80	8.80	44.0	22,000,000	8.78
TOTAL COMMUNITY CAPITAL COSTS[a]	12,550	40,901,612	214.92	214.92	206.39	206.39	206.39	1049.0		

[a] Totals may not add due to rounding.

[b] Based on 1983 figures when treatment is fully implemented.

TABLE G-7

TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	1,261	16,390,692	32.89	65.78	98.67	131.56	164.45	130,005	10.03
NO_3	577	1,667,500	3.15	6.31	9.46	12.61	15.77	27,232	9.45
CHLORINATION	3,296	9,558,782	3.13	6.26	6.26	6.26	6.26	1,894	.66
MERCURY	456	2,162,502	3.59	7.18	10.77	14.37	17.96	39,246	8.30
SELENIUM	226	604,464	1.27	2.54	3.80	5.07	6.34	27,968	10.49
CADMIUM	105	250,860	.52	1.04	1.56	2.08	2.61	24,739	10.39
LEAD	406	1,330,435	.02	.04	.07	.09	.11	270	.08
FLUORIDE	930	2,689,518	1.76	3.52	5.27	7.03	8.79	9,423	3.27
CHROMIUM	79	186,145	.41	.82	1.24	1.65	2.06	25,861	10.96
BARIUM	28	62,712	.15	.30	.45	.60	.75	26,660	11.89
ARSENIC	79	186,145	.12	.24	.37	.49	.61	7,652	3.24
TOTAL PUBLICLY-OWNED COMMUNITY O&M COSTS[a]			47.02	94.04	137.93	181.81	225.70		

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[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-8

TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	865	2,712,679	4.62	9.65	14.47	19.29	24.12	28,011	8.89
NO_3	396	275,973	.46	.92	1.39	1.85	2.31	5,867	8.38
CHLORINATION	2,261	1,581,989	.46	.92	.92	.92	.92	408	.58
MERCURY	313	357,897	.53	1.05	1.58	2.11	2.63	8,456	7.36
SELENIUM	155	100,039	.19	.37	.56	.74	.93	6,026	9.29
CADMIUM	72	41,518	.08	.15	.23	.31	.36	5,330	9.20
LEAD	278	220,189	.00	.01	.01	.01	.02	58	.07
FLUORIDE	638	445,118	.26	.52	.77	1.03	1.29	2,030	2.90
CHROMIUM	55	31,136	.06	.12	.18	.24	.30	5,572	9.71
BARIUM	19	10,379	.02	.04	.07	.09	.11	5,744	10.53
ARSENIC	55	31,136	.02	.04	.05	.07	.09	1,649	2.87
TOTAL INVESTOR-OWNED COMMUNITY O&M COSTS[a]			6.90	13.79	20.23	26.66	33.10		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-9

TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS
(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	2,126	19,103,371	37.71	75.43	113.14	150.86	188.57	88,697	9.87
NO_3	973	1,943,473	3.62	7.23	10.85	14.46	18.08	18,580	9.30
CHLORINATION	5,557	11,140,771	3.59	7.18	7.18	7.18	7.18	1,292	.64
MERCURY	769	2,520,399	4.12	8.24	12.35	16.47	20.59	26,776	8.17
SELENIUM	381	704,503	1.45	2.91	4.36	5.82	7.27	19,081	10.32
CADMIUM	177	292,376	.60	1.19	1.79	2.39	2.99	16,879	10.22
LEAD	684	1,550,624	.03	.05	.08	.10	.13	184	.08
FLUORIDE	1,566	3,134,636	2.02	4.03	6.05	8.06	10.08	6,429	3.22
CHROMIUM	134	219,283	.47	.95	1.42	1.89	2.36	17,644	10.78
BARIUM	47	73,091	.17	.34	.51	.68	.85	18,169	11.70
ARSENIC	134	219,283	.14	.28	.42	.56	.70	5,221	3.19
TOTAL COMMUNITY O&M COSTS			53.92	107.83	158.15	208.46	258.80		

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[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-10

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	676	41,056	.11	.22	.32	.41	.51	754	12.41
100-499	2,827	734,370	.88	1.75	2.50	3.25	4.00	1,413	5.44
500-999	1,192	859,895	.64	1.28	1.81	2.35	2.88	2,416	3.35
1,000-2,499	1,208	1,857,829	.94	1.88	2.65	3.42	4.19	3,466	2.25
2,500-4,999	604	2,086,812	2.79	5.58	8.18	10.77	13.37	22,119	6.41
5,000-9,999	378	2,579,288	3.24	6.48	9.46	12.43	15.40	40,752	5.97
10,000-99,999	516	12,390,476	13.85	27.70	40.35	52.99	65.64	127,295	5.30
100,000-999,999	42	9,574,236	12.89	25.79	37.80	49.82	61.84	1,462,654	6.46
>1,000,000	2	5,010,781	11.60	23.20	34.80	46.40	58.00	29,000,000	11.58
TOTAL PUBLICLY-OWNED COMMUNITY O&M COSTS[a]	7,444	35,134,744	46.94	93.88	137.86	181.84	225.82		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-11

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,070	125,838	.34	.67	.97	1.27	1.56	754	12.41
100-499	2,212	574,666	.69	1.37	1.96	2.54	3.13	1,413	5.44
500-999	370	267,097	.20	.40	.56	.73	.90	2,418	3.35
1,000-2,499	242	372,458	.19	.38	.53	.69	.84	3,466	2.25
2,500-4,999	86	295,394	.39	.79	1.16	1.53	1.89	22,119	6.41
5,000-9,999	49	335,162	.42	.84	1.23	1.61	2.00	40,752	5.97
10,000-99,999	66	1,594,260	1.76	3.56	5.19	6.82	8.45	127,295	5.30
100,000-999,999	10	2,202,192	2.97	5.93	8.70	11.46	14.22	1,462,654	6.46
>1,000,000									
TOTAL INVESTOR-OWNED COMMUNITY O&M COSTS[a]	5,106	5,767,066	6.97	13.95	20.29	26.64	32.99		

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[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-12

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM
(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,746	166,694	.45	.89	1.29	1.66	2.07	754	12.41
100-499	5,039	1,309,038	1.56	3.12	4.46	5.79	7.12	1,413	5.44
500-999	1,562	1,126,992	.84	1.67	2.37	3.06	3.78	2,418	3.35
1,000-2,499	1,450	2,230,287	1.13	2.26	3.18	4.10	5.03	3,466	2.25
2,500-4,999	690	2,382,206	3.19	6.37	9.33	12.30	15.26	22,119	6.41
5,000-9,999	427	2,914,450	3.66	7.33	10.69	14.04	17.40	40,752	5.97
10,000-99,999	582	13,964,736	15.63	31.27	45.54	59.61	74.09	127,295	5.30
100,000-999,999	52	11,776,428	15.86	31.72	46.50	61.26	76.06	1,462,654	6.46
>1,000,000	2	5,010,781	11.60	23.20	34.80	46.40	58.00	29,000,000	11.58
TOTAL COMMUNITY O&M COSTS[a]	12,550	40,901,812	53.92	107.83	158.15	208.46	258.80		

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE G-13

TOTAL ANNUALIZED TOTAL COSTS[a] BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	1,261	16,390,692	41.62	83.25	124.87	166.50	208.13	164,530	12.70
NO_3	577	1,667,500	8.12	16.25	24.37	40.60	48.72	148,085	25.64
CHLORINATION	3,296	9,558,782	4.11	8.22	8.22	8.22	8.22	2,493	0.86
MERCURY	456	2,162,502	9.18	18.37	27.55	36.74	45.92	201,412	21.24
SELENIUM	226	604,464	3.26	6.51	9.77	13.03	16.28	144,097	26.96
CADMIUM	105	250,860	1.34	2.68	4.03	5.37	6.71	127,790	26.73
LEAD	406	1,330,435	0.08	0.17	0.25	0.33	0.42	2,044	0.31
FLUORIDE	930	2,689,518	2.41	4.82	7.24	9.65	12.06	25,940	4.48
CHROMIUM	79	188,145	1.06	2.12	3.18	4.24	5.30	134,127	28.18
BARIUM	28	62,712	0.38	0.77	1.15	1.54	1.92	137,071	30.95
ARSENIC	79	188,145	0.17	0.35	0.52	0.69	0.87	21,924	4.61
SUBTOTAL PUBLICLY-OWNED COMMUNITY ANNUALIZED TOTAL COSTS[c]			71.73	143.51	211.15	278.79	346.43		
MONITORING			14.74	14.74	14.74	14.74	14.74		
TOTAL COMMUNITY[c]			86.47	153.25	225.89	293.53	361.17		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

TABLE G-14

TOTAL ANNUALIZED TOTAL COSTS[a] BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	865	2,712,679	6.71	13.41	20.12	26.82	33.54	38,769	12.37
NO_3	396	275,973	1.53	3.07	4.60	6.14	7.67	19,366	27.79
CHLORINATION	2,261	1,581,989	0.67	1.35	1.35	1.35	1.35	597	0.85
MERCURY	313	357,897	1.74	3.48	5.21	6.95	8.69	36,761	24.28
SELENIUM	155	100,039	0.62	1.24	1.86	2.48	3.10	19,993	30.99
CADMIUM	72	41,518	0.26	0.52	0.77	1.03	1.29	17,902	31.43
LEAD	278	220,189	0.01	0.02	0.03	0.04	0.06	216	0.27
FLUORIDE	638	445,118	0.40	0.80	1.20	1.61	2.01	3,146	4.51
CHROMIUM	55	31,138	0.20	0.40	0.60	0.80	1.00	18,182	32.25
BARIUM	19	10,379	0.07	0.14	0.21	0.28	0.35	18,526	35.20
ARSENIC	55	31,138	0.03	0.06	0.09	0.12	0.16	2,836	5.03
SUBTOTAL INVESTOR-OWNED COMMUNITY ANNUALIZED TOTAL COSTS[c]			12.24	24.49	36.04	47.62	59.22		
MONITORING			4.66	4.66	4.66	4.66	4.66		
TOTAL COMMUNITY[c]			16.90	29.15	40.70	52.28	63.38		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

TABLE G-15

TOTAL ANNUALIZED TOTAL COSTS BY TREATMENT PROCESS[a]
(Millions of Dollars Unless Otherwise Noted)

PROCESS	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
CLARIFICATION	2,126	19,103,371	48.33	96.66	145.00	193.33	241.66	113,668	12.65
NO_3	973	1,943,473	9.67	19.33	29.00	38.66	48.33	49,667	24.87
CHLORINATION	5,557	11,140,771	4.78	9.57	9.57	9.57	9.57	1,722	0.86
MERCURY	769	2,520,399	10.92	21.84	32.77	43.69	54.61	71,009	21.84
SELENIUM	381	704,503	3.87	7.73	11.60	15.47	19.33	50,740	27.47
CADMIUM	177	292,378	1.60	3.20	4.80	6.40	8.00	45,186	27.39
LEAD	684	1,550,624	0.11	0.21	0.32	0.43	0.54	782	0.34
FLUORIDE	1,568	3,134,636	2.81	5.62	8.44	11.25	14.07	8,972	4.48
CHROMIUM	134	219,283	1.26	2.52	3.78	5.04	6.30	47,135	28.80
BARIUM	47	73,091	0.45	0.91	1.36	1.82	2.27	48,319	31.10
ARSENIC	134	219,283	0.20	0.41	0.61	0.82	1.02	7,627	4.67
SUBTOTAL COMMUNITY O&M COSTS AND CAPITAL COSTS[c]			84.00	168.00	247.25	326.48	405.70		
MONITORING			19.40	19.40	19.40	19.40	19.40		
SUBTOTAL COMMUNITY[c]			103.40	187.40	266.65	345.88	425.10		
SUBTOTAL NON-COMMUNITY[c]			10.00	10.00	10.70	11.50	12.30		
TOTAL[c]			113.40	197.40	277.35	357.38	437.40		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

TABLE G-16

TOTAL ANNUALIZED TOTAL COSTS[a] BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	676	41,056	0.31	0.62	0.91	1.16	1.45	2,284	37.66
100-499	2,827	734,370	2.43	4.88	7.05	9.26	11.45	4,049	15.60
500-999	1,192	859,895	1.74	3.48	5.04	6.62	8.20	6,879	9.54
1,000-2,499	1,208	1,857,829	2.56	5.12	7.43	9.75	12.07	9,993	6.50
2,500-4,999	604	2,086,812	5.37	10.73	15.82	20.89	25.97	42,997	12.45
5,000-9,999	378	2,579,288	6.15	12.30	18.07	23.85	29.62	78,370	11.49
10,000-99,999	516	12,390,476	23.31	46.62	68.42	90.21	112.01	217,070	9.04
100,000-999,999	42	9,574,236	16.95	33.88	49.30	65.74	81.66	1,944,285	8.52
>1,000,000	2	5,010,781	12.83	25.67	38.50	51.33	64.16	32,080,000	12.80
SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c]	7,444	35,134,744	71.65	143.30	210.54	278.81	346.59		
MONITORING			14.74	14.74	14.74	14.74	14.74		
TOTAL COMMUNITY[c]			86.39	158.04	225.28	293.55	361.33		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

TABLE G-17

TOTAL ANNUALIZED TOTAL COSTS[a] BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,070	125,838	0.95	1.90	2.71	3.59	4.44	2,145	31.04
100-499	2,212	574,668	1.91	3.82	5.53	7.24	8.95	4,048	15.60
500-999	370	267,097	0.54	1.08	1.57	2.06	2.55	6,897	9.56
1,000-2,499	242	372,458	0.51	1.03	1.49	1.95	2.42	10,008	6.51
2,500-4,999	86	295,394	0.76	1.51	2.24	2.97	3.67	42,651	12.43
5,000-9,999	49	335,162	0.80	1.60	2.35	3.10	3.85	78,531	11.48
10,000-99,999	66	1,594,260	3.00	6.00	8.80	11.60	14.41	218,393	9.04
100,000-999,999	10	2,202,192	3.90	7.80	11.46	15.12	18.78	1,878,400	7.48
>1,000,000									
SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c]	5,106	5,767,068	12.37	24.74	36.15	47.63	59.07		
MONITORING			4.66	4.66	4.66	4.66	4.66		
TOTAL COMMUNITY[c]			17.03	29.40	40.81	52.29	63.73		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

TABLE G-18

TOTAL ANNUALIZED TOTAL COSTS[a] BY SIZE OF SYSTEM
(Millions of Dollars Unless Otherwise Noted)

POPULATION SIZE CATEGORY	TOTAL # OF PLANTS	TOTAL POPULATION AFFECTED	1979	1980	1981	1982	1983	TOTAL PER PLANT (DOLLARS)[b]	TOTAL PER CAPITA (DOLLARS)[b]
25-99	2,746	166,894	1.26	2.52	3.64	4.76	5.89	2,144	35.26
100-499	5,039	1,309.038	4.34	8.67	12.59	16.51	20.39	4,046	15.56
500-999	1,562	1,126,992	2.28	4.56	6.61	8.67	10.75	6,876	9.53
1,000-2,499	1,450	2,230,287	3.07	6.15	8.93	11.71	14.49	9,997	6.50
2,500-4,999	690	2,382,206	6.13	12.26	18.02	23.82	29.64	42,956	12.44
5,000-9,999	427	2,914,450	6.95	13.88	20.42	26.95	33.47	78,391	11.49
10,000-99,999	582	13,984,736	26.31	52.62	77.22	101.82	126.42	217,213	9.04
100,000-999,999	52	11,776,428	20.84	41.69	61.27	80.86	100.45	1,931,708	6.53
>1,000,000	2	5,010,781	12.83	25.66	38.50	51.33	64.16	32,080,000	12.60
SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c]	12,550	40,901,812	84.00	168.01	247.20	326.43	405.66		
MONITORING			19.40	19.40	19.40	19.40	19.40		
SUBTOTAL COMMUNITY[c]			103.40	187.41	266.60	345.83	425.06		
SUBTOTAL NON-COMMUNITY[c]			10.00	10.00	10.70	11.50	12.30		
TOTAL[c]			113.40	197.41	277.30	357.33	437.36		

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership of 3 percent to cover taxes, insurance, etc.

[b] Based on 1983 figures when treatment is fully implemented.

[c] Totals may not add due to rounding.

APPENDIX H

WATER SUPPLY SYSTEM QUESTIONNAIRES

A questionnaire (Figure H-1) was sent to the 207 water supply systems which were found to exceed one or more maximum contaminant levels, as determined in the 1969 CWSS study. Of these 207 systems, replies were obtained from 114 systems (Table H-1); of the remaining 93 systems, 17 no longer operate, 17 others have consolidated, and 59 could not be contacted.

This initial questionnaire dealt mainly with treatment and analysis costs and techniques employed. The responses concerning analysis are summarized in Table H-2. This shows that over 63 percent of the inorganic and 70 percent of the organic and bacteriological analyses are done by some form of governmental laboratory. Another important finding of the study is that seven out of the eight water supply systems contacted which distribute purchased water do not analyse the water in their distribution system.

The responses to the treatment questions indicate that only 15 systems have changed their treatment techniques since discovering their violation on 1969. These changes are listed in Table H-3.

A second telephone questionnaire (Figure H-2) was utilized to supplement the financial and cost data information of the 114 respondents listed above.

TABLE H-1

SUMMARY OF RESPONDENTS TO WATER SUPPLY SYSTEM QUESTIONNAIRE

Number sent out	207
Systems which no longer operate	17
Systems which could not be located	43
Systems which have consolidated and therefore no response	17
Systems which operate seasonally only and no response	16
Municipal (and other governmental agency) systems responding	78
Private systems responding	36
Total	207

TABLE H-2

SUMMARY OF RESPONSES FROM WATER SUPPLY SYSTEMS QUESTIONNAIRE

1. Costs of Analysis	Range ($)
1) Inorganic[a,b]	0 - 144.00
2) Organic[a,b]	0 - 60.00
3) Bacteriological[a]	0 - 7.50

2. Analysis Done By:

	STATE	COUNTY	MUNICIPAL LAB	PRIVATE LAB	OTHER
1) Inorganic	27	5	8	23	3
2) Organic	23	5	6	15	3
3) Bacteriological	27	7	11	18	4

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[a] $0 costs are for those systems where state or other governmental agency incurs the cost of analysis.

[b] The costs for inorganic and organic analyses are for partial analyses only.

TABLE H-3

CHANGES IN TREATMENT TECHNIQUES TO CORRECT FOR VIOLATIONS OF 1969 PHS STANDARDS

CONTAMINANT	NEW TREATMENT
NO_3	Blending
Pb	pH Control
Fluoride	New well
Turbidity	Coagulation, filtration, sedimentation
Turbidity	New source
NO_3	Blending
Se	Blending
NO_3	Blending
Fluoride	Inject less fluoride into system
Pb	Change pipes
Coliform	Chlorinator
NO_3	Blending
Pb	Flush system
Turbidity	Coagulation, filtration, sedimentation
Coliform	Chlorinator

FIGURE H-1

QUESTIONNAIRE TO WATER SUPPLY SYSTEMS

1. NAME OF SUPPLY: ____

2. LOCATION: ____

3. PERSON FILLING OUT QUESTIONNAIRE: __________________________

4. PHONE # ____

5. POPULATION SERVED: ____

6. CURRENT PRODUCTION (MGD): _____________________________________

7. TOTAL VOLUME SUPPLIED IN 1974
   (SPECIFY UNITS): ____

8. TREATMENT METHODS USED: (PLEASE CHECK)

			TREATMENT PROCESS ADDED SINCE 1970	
	YES	NO	YES	NO
a. Disinfection	____	____	____	____
b. Coagulation	____	____	____	____
c. Sand Filter	____	____	____	____
d. Fluoridation	____	____	____	____
e. Taste and Odor Control	____	____	____	____
f. Lime Softening	____	____	____	____
g. Ion Exchange	____	____	____	____
h. Settling	____	____	____	____
i. Iron Removal	____	____	____	____
j. Other (Please List)	______________________________ ______________________________			
k. Do you use zeolite for:				
1) Iron Removal	____	____		
2) Softening	____	____		

9. ANALYSIS INFORMATION

	State Lab	Municipal Lab	Private Lab	Other
a. Inorganic Analysis Done By:	___	___	___	___

b. Date of Last Inorganic Analysis: ______________________

c. Cost of Analysis: ______________________

	State Lab	Municipal Lab	Private Lab	Other
d. Organic & Pesticide Done By:	___	___	___	___

e. Date of Last Organic Analysis: ______________________

f. Cost of Analysis: ______________________

	State Lab	Municipal Lab	Private Lab	Other
g. Bacteriological Analysis Done By:	___	___	___	___

h. Date of Last Bacteriological Analysis: ______________________

i. Cost of Analysis: ______________________

10. QUALITY OF INFLUENT WATER

a. Do you Treat for a Particular Contaminant in the Influent Water? (e.g., Lead, Coliform, CCE, etc.) ______________________

b. How Frequently do you Monitor the Influent Water?

Daily	Monthly	Yearly	Other
___	___	___	___

11. QUALITY OF EFFLUENT WATER

a. In 1969 you exceeded the 1962 PHS Standard for ______________ (i) and ______________ (ii). Please list any corrective actions taken to rectify this violation.

(i) ____________

Capital Cost	____________
Annual Operating Cost (OVHD & Maint.)	____________
Total Annual Cost	____________

(ii) ____________

Capital Cost ____________

Annual Operating Cost (OVHD & Maint.) ____________

Total Annual Cost ____________

b. Are you now in Compliance with These Standards? ____________

c. What are your Current Concentrations of These Parameters?

____________ ____________

____________ ____________

____________ ____________

____________ ____________

d. Have you have any New Problems with Other Pollutants? ______

(If so, Please Specify) ____________________________

12. CURRENT OVERHEAD AND MAINTENANCE COSTS FOR TREATMENT

	$/Unit of Time
a. Labor	____________
b. Supplies	____________
c. Chemicals (Please List at end of Questionnaire)	____________
d. Electric Power	____________
e. Total	____________

13. WHAT ARE THE ANNUAL FIXED COSTS OF YOUR PLANT? $____________

Year ____________

14. HOW MANY EMPLOYEES IN WATER SYSTEM:

Full Time	Part Time
________	________

15. WHAT IS THE RATE STRUCTURE FOR WATER SALES?

AMOUNT	UNIT (Gal., Cu.Ft.)
________	________

16. METHOD OF CHARGING? Meters_____ Flat Rate_____ Other_____

17. PROFITS $__________ Year __________

18. DEPRECIATION $__________ Year __________

19. ESTIMATES ON UPGRADING CURRENT TREATMENT FACILITIES:

(If you are planning an expansion or change in treatment techniques, please specify contaminant you will treat for.)

a. Capital Costs

Land $__________

Equipment $__________

Site Development $__________

Total $__________

b. O&M Costs

Labor $__________

Supplies $__________

Chemicals $__________

Electric Power $__________

Other $__________

Total $__________

20. CAPITAL FINANCING

	Amount Realized	Interest or Dividend Rate(%)
a. General Obligation Bonds	$__________	__________
b. Revenue Bonds	$__________	__________
c. Debenture Bonds	$__________	__________
d. Mortgage Bonds	$__________	__________
e. Bank Loans	$__________	__________

f. Preferred Stock $__________ __________

g. Common Stock $__________ __________

h. Other $__________ __________

__________ __________

i. Total $__________ __________

21. The Proposed Interim Standards allow for total substitution of chlorine residual monitoring in place of coliform density measurements for systems serving 4,900 or fewer persons provided the system maintains a residual of no less than 0.3 mg/l free chlorine. If the system serves more than 4,900 people, chlorine residual monitoring may be substituted for not more than 75% of the required coliform measurements if a residual of no less than 0.2 mg/l free chlorine is maintained in the public water distribution system. This substitution would reduce the overall monitoring costs of the Proposed Standards considerably. Do you feel that your system would use this chlorine residual option? YES____ NO____

22. COMMENTS:

FIGURE H-2

CODE: ____________

1. NAME OF WATER SUPPLY: ______________________________

2. PHONE #: _____ ______

3. PERSON SUPPLYING INFO.: ______________________________

4. OWNERSHIP ☐ MUNICIPAL ☐ PRIVATE ☐ OTHER GOV'T

RATE STRUCTURE:

5. ____dollars for____units RESIDENTIAL or flat rate of $________

6. ____dollars for____units COMMERCIAL or flat rate of $________

7. ____dollars for____units INDUSTRIAL or flat rate of $________

CURRENT REVENUES RAISED FROM: Answer either in $ or % of total.

8. ________RESIDENTIAL

9. ________COMMERCIAL

10. ________INDUSTRIAL

11. ________TAX REVENUES Either as SURPLUS (+) or SUBSIDY (-) or

________TOTAL REVENUE If can't get #'s 8, 9, 10, or 11

OF CUSTOMERS:

12. RESIDENTIAL________

13. COMMERCIAL ________

14. INDUSTRIAL ________

15. CURRENT ANNUAL O&M COST INCLUDING: 🄰 OPERATION & MAINTENANCE + 🄱 INTEREST ON DEBT IF ANY, 🄲 AMOUNT OF MONEY PUT ASIDE TO RETIRE DEBT, IF ANY: ______________________________

16. WHAT IS TOTAL PRODUCTION? ______________________________

17. WHAT IS TOTAL POPULATION SERVED? ______________________________

18. 🄰 WHO ARE THE 2 OR 3 LARGEST CUSTOMERS AND HOW MUCH WATER DO THEY USE? ______________________________

____

B IF INDUSTRIAL CONCERN WHAT DO THEY PRODUCE?____________

____

C WHAT IS TOTAL BILL OF CONCERN?_______________________

19. WHAT IS A TYPICAL RESIDENTIAL BILL?_________________________

20. IS WATER SYSTEM AN INDEPENDENT AGENCY ____ OR TIED IN WITH OTHER AGENCIES (SEWER, ETC.)?_________________________________

21. HOW DOES THE SYSTEM FINANCE EXPANSION? ____ BONDS?____LOANS? ____SHARES?

22. WHAT IS THE CURRENT INDEBTEDNESS OF THE SYSTEM?______________

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